A MODEL TO INVESTIGATE THE IMPACT OF FLOODING ON THE VULNERABILITY OF VALUE OF COMMERCIAL PROPERTIES

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This work or any part thereof has not previously been submitted in any form to the University or to any other body whether for the purpose of assessment, publication or for any other purpose. Save for any express acknowledgements, references and/or bibliographies cited in the work, I confirm that the intellectual content of the work is the result of my own efforts and no other person.

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Date…25.01.2015

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ABSTRACT

Flooding has the potential to have significant impact on the value of properties depending on the level of inherent vulnerability. Experts argue that it is not the actual risk but the perception of risk among property holders that influences vulnerability of value. The hypothesis that changing perception of flood risk could make property value vulnerable in the market is the main focus of the research. This dimension of research has received very low attention in commercial property literature.The existing knowledge base of flooding and property value reveals that focus has been largely associated with residential properties. Conceptual understanding of the extent and scale of the effect of flooding on the vulnerability of property value of commercial properties would be worthwhile for relevant stakeholders.

The research methodology follows a quantitative approach with sequential application: of literature review, conceptual model generation, data collection from primary and secondary sources with remote questionnaire survey of selected study areas in the UK. The conceptual model was operationalised using analysis and interpretation of the collected data and finally cross validated with secondary data gained from commercial real estate experts .

The strength of this research lies in the conceptualisation of the subject matter of property value in the context of flood vulnerability.This work provides innovative conceptual insight towards business vulnerability and vulnerability of value. The variables contributing towards vulnerability were hierarchically ranked using both collected data and deductive methods. The patterns of impact and recovery analysis emphasized that within the commercial sector indirect effects of flooding should be given equal importance with direct damages.The implication of perception on the vulnerability of property value showed a slightly different picture from business vulnerability in the chosen study areas when differentiated based on flood experience. In a nutshell the study reflected that the commercial property sector does not take flooding as one of their priorities. This is in part due to differential attitude towards risk of the population within the flood plain based on their knowledge and experience of flooding. The perception of stakeholders towards vulnerability of value can change with increasing magnitude and severity of floods and it is possible that the implications on market value of commercial properties will be visible in the future. Practitioners and researchers will find this study useful in developing an understanding of the vulnerability of commercial property value in the context of changing flood risk.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

RICS Royal Institution of Chartered Surveyors

EA Environment Agency

BIS Department of Business Innovation and Skills

ABI Association of British Insurers

IPCC International Panel of Climate Change

GIS Geographic Information Systems

ODPM Office of Deputy Prime Minister

VOA Valuation office Agency

BV Business Vulnerability

VV Vulnerability of Value

CHAPTER 1. INTRODUCTION

Changing value of property due to detrimental environmental conditions can be a major concern for property holders (Mundy, 1990). Flooding is one such environmental hazard that has the potential to have a significant impact on the value of property at risk . Flooding is one of the most damaging natural disasters and due to high level of economic impact; as a result it is receiving increasing attention in the scientific community owing to the prospect of several projections of increased magnitude and frequency (Hall *et al.*, 2003; Jha *et al.*, 2012). The value of a commercial property can be affected directly by physical impact of flooding or indirectly based on the social, economic and political assumptions associated with the condition of the asset at risk (RICS, 2011). This is especially important for commercial properties which are susceptible to initial business interruption and closure caused by flood events and lingering effect of stigma affecting value of property in the long run (Vatsa, 2004; Ingirige, Jones & Proverbs, 2010; Mundy, 1992).

Commercial properties are a central component of national assets and Gross Domestic Product (GDP) and therefore their value is of broad significance to direct property stakeholders but also local and national economic prosperity. Risk analysis firm Maplecroft reported UK ranking 7th highest among 197 countries assessed in terms of economic exposure to flooding (Nichols, 2014). With approximately 185,000 commercial properties at risk, there is clearly a need to investigate the potential impact of flooding on the commercial property sector (ROOTS, 2010; Environment Agency, 2009b). Within the UK, for example, commercial property sector forms a significant portion of the economy with an estimated turnover of £3200 billion and employing about 22.8 million people with an average growth rate of 2.2% since 2008 (BIS, 2010). The UK commercial sector is dominated by large assets and requires significant capital investment, operational and maintenance costs and is highly vulnerable to flooding (Kenney *et al.*, 2006). The market value of commercial properties was about £801 billion in 2011 in the UK accounting for approximately 15.8% of the value of total buildings and 2.2% of total assets (RICS, 2012b). It is recognised that the assessment of the potential exposure and loss in value of the existing assets is a crucial component in plans to improve public

administration. An estimation of potential impact on endangered asset value is required for loss avoidance in future.

Despite the importance of the commercial sector to the national economy, most current research studies in the context of flood risk management are either partly or fully focused on residential properties (Kenney *et al.*, 2006; Gissing, 2003; Lamond, 2008). However "value" of property is a subjective term that is open to different interpretations and maintenance of value has implications to local economies as well as to property owners and occupiers. Therefore objective understanding of the attitudes of the relevant stakeholders within the commercial property sector towards flood risk and property value is also necessary. This enhances the need for better analysis and evaluation of the potential impacts of flooding on the value of commercial properties (Halcrow & DEFRA, 2001; Proverbs & Soetanto, 2004). An understanding of the extent and scale of the effect of flooding on value of commercial properties would provide useful insight for the benefit of key stakeholders. Based on the above discussion, an investigation of the impact of flood risk on the value of commercial property sector represents a timely and needy topic for research.

1.1 RESEARCH JUSTIFICATION AND CONTEXT

The commercial property sector has been largely neglected in flood risk management research. Flood risk research ranges its domain from purely physical science to social, economics and political studies. Recent developments towards integrated flood research have incorporated the concept of vulnerability of flood affected communities to various impacts including physical and social effects (Adger, 2006; Cutter, 1996). Alternatively, valuation research within the real estate sector, particularly that relating to environmental conditions is often focussed on empirical, market data based studies for understanding changes in value of property. The current investigation is located broadly between these two domains of research: flood risk management and real estate valuation. The focus of the study is to anticipate the effect of flood risk on businesses and subsequently on value of property rather than to attempt to measure the historical impact of flooding in the commercial market to date. The intention is to identify factors that make property vulnerable to flooding immediately or in the long term after an event. Furthermore to

understand the perception of the both flood affected and unaffected stakeholders towards long term effects on property value. The understanding is based on the concept that flood vulnerability of commercial properties can have an impact on vulnerability of property value.

Straightforward empirical market measurement was eschewed for multiple reasons. Assets in the commercial property sector are usually defined with an intention of generating profit from their possession in terms of their usage. The concept of value is a bundle of goods and can be viewed from different vantage points and perspectives (Rosen, 1974). The feasibility and quality of empirical research into the effect of environmental input on the output of economics of real estate value usually depends heavily upon access to comprehensive and disaggregated data for reliable results. In-spite of the several key data holding agencies holding data for market trend and index purposes, in the case of individual locations, and detailed and specific environmental studies for commercial properties the data available is very limited (Byrne, 2005).

Researchers in the real estate sector also indicated that confidentiality clauses and inaccessibility of Government held records can pose barriers in data dis-aggregation (Wyatt, 1995). Such lack of coverage can have large impact on empirical studies dealing in fewer and dispersed properties affected by flooding in selected areas, resulting in weak statistical power and lack of confidence in outputs. The fragmented and incomplete nature of data as a result of lack of cooperation from the originators and other administrative processes also affect quality of data (Adair *et al.*, 1998). There are also investigations regarding issues related to accuracy of the data as market transactions are becoming more complex (Fuerst *et al.*, 2010).

Finally research suggests that even when data is available the impact of flooding on market value is difficult to assess from the current market due to causes such as imperfect information, risk perception and inadequate availability of insurance. However, over time, with more transparency of information, changes in risk profiles, and changing risk perception, there might be less dependency on insurance and with more awareness of the general level of risk. Therefore the locations which are considered to be more secure in terms of future flood risk will be

more desirable and economically less vulnerable in the context of the at risk population (Pottinger & Tanton, 2011).

Another aspect of knowledge gap that commercial property research often suffers is the lack of attention in spatial distribution of research outputs. There are no standard geographical definitions of market in the commercial property sector and therefore fuzzy definitions are often used to delineate sub-markets (Fuerst *et al.*, 2010; Wyatt, 1995). This often led to misinterpretation due to lack of formal definitions. Standard spatial units such as post code or electoral level can provide new ventures towards establishing data release in a universal format.

Valuations of property in terms of geographical differences are often handled by valuers in a subjective manner. Lack of adequate data can lead to reliance on the personal knowledge and experience of valuers for property valuations. Effect on value is a forward looking concept which is determined by the past and present attributes of property, their different characteristics as well as market conditions. To understand the effects of certain external environmental perturbation (such as flooding) on property value a 'reconciliation of the factors affecting characteristics of property and transactions that cause prices for real estate to vary' are essential (Wyatt, 1995). Since transaction data of such comprehensive extent are not available alternative techniques are required to develop better understanding of the complex and diverse nature of commercial property value.

The effect on value and the readiness to pay for property depends on various social and economic factors, especially when it is assessed in the context of natural hazards. Experts argue that it is not the actual risk but the perception of risk among property holders that adds more to the effect of value change (Eakin, 2006; Syms, 1997). To identify and decide on dominant factors researchers have attempted to bring in behavioural perspective of a range of individuals who have some involvement with the property as relevant stakeholder in research (Cowley, 2007; Syms, 1997). These subjective probabilities generated through perception can overtop the probabilities of actual hazard (Ihlanfeldt & Taylor, 2004). Therefore it is not only the market that acts as a critical factor in determining value of properties but also there are other socio-psychological factors that can have an impact.

The requirement of this research is grounded in better conceptual understanding and identification of the factors affecting flood vulnerability and property value and their interrelationships in a heterogeneous environment of commercial property sector not just the market value. To meet this requirement vulnerability assessment has been identified as a useful tool. The intention is to investigate conceptually the relationship between flood vulnerability of commercial property and how they perceive changes in level of vulnerability can impact on property value (UNISDR, 2004; Birkmann, 2006).

The concept of vulnerability consists of two opposing forces: the processes that cause vulnerability and the physical exposure to hazards such as flooding (Thywissen, 2006; Wisner *et al.*, 2003). In the context of this research, damage of commercial properties due to flooding is greatly associated with continuous interaction between natural and human systems. The effect of physical and economic damage caused during flood events can be attributed to the performance of focal factors which can affect property value. The motivation is on identifying an integrated framework of knowledge that is sustainable to the changing physical and socio-economic environment and determining the effects on potential changes in value of property. Based on the above discussion and understanding the main aim and objectives of the research are stated below.

1.2 AIMS AND OBJECTIVES OF THE STUDY

The aim of the research is to investigate the ***relationship between the vulnerability of commercial property value and the risk of flooding.*** To achieve this aim the research objectives are set as follows:

1. To review the extant body of literature to develop an understanding of the theories, principles and concepts of vulnerability in the context of commercial properties.

2. To critically review the literature to develop an understanding of the existing patterns, themes and issues associated with commercial property value in the context of environmental hazards particularly flooding.

3. To develop a conceptual model of the relationship between the vulnerability of commercial property values, the risk of flooding, property and business characteristics and the perceptions of market stakeholders.

4. To operationalise and validate the conceptual model through collection of hazard, risk and perception related data .

5. To analyse the collected data to reveal patterns of vulnerability of commercial businesses and property value towards flooding using appropriate statistical and spatial vulnerability analysis methods.

6.To spatially represent empirical data in the form of maps to illustrate the potential application of the operationalised conceptual model.

7. To cross validate the conceptual outputs using perspectives from commercial real estate experts.

8. To draw conclusions on how flooding affects the vulnerability of commercial property values and make recommendations for future research.

1.3 SCOPE AND PHILOSOPHY OF RESEARCH

The reasoning of the research is largely quantitative in nature which corresponds to identification of impact variables through instrumentation rather than 'reduction' and 'interpretation' (Creswell, 2003). This is a multi-disciplinary research which embraces the concepts from different physical and social sciences. The research takes place in the context of observed facts and constructed ideas based on review of available literature. Direct correspondence with the stakeholders (property holders and property experts) through appropriate forms of survey was undertaken to gather empirical evidence of conceptual outputs. This is mainly a deductive pragmatic research where conceptual and empirical characteristics are both emphasised.

The term commercial property is extensive. Therefore the unit of analysis was dependent upon risk status of commercial properties of all sizes and types. Risk status was based on the flood hazard maps provided by the Environment Agency. The sampled population involved different kinds of facilities depending upon the

type of property (retail, warehouse, office,and factories) and geographically distributed in two locations in the UK. The study is pragmatically pluralistic in approach with a balance between theoretical knowledge base and empirical evidence.

A number of uncertainties were identified based on demanding data availability and collection; model building, data analysis, interpretation in a limited timeframe are anticipated. Complexity of extensive nature of commercial property sector is one of the major difficulties for this study. It was not possible to do a very detailed study in various locations taking into account all commercial properties in the UK. Although the plan was not to restrict the data collection to any particular sector. However, after the data collection four commercial property sectors such as manufacturing, service, retail and other uses were observed to predominate the markets of the selected study areas. Therefore the reasearch dealt within the four sectors of property.

The study also cannot take into account detailed information regarding all types of flooding. For instance only fluvial flooding data was available from the Environment Agency at the time of secondary data collection. Other flood sources such as surface water flooding, ground water flooding and so on are not considered primarily as a result of unavailability of data in the earlier stages of research. However, while collecting primary data respondents indicated the impact of flooding not only from river but also surface water, ground water and heavy rainfall, therefore other flood sources are also discussed within the results. Due to the limited timeframe and resources, secondary risk data that was freely available for research purpose was used at a post code level analysis. Analysis up to the level of individual property is possible and recommended for future.

There are different type of property values however for the sake of simplicity and time constrains this study focussed only on perceived changes in market value by stakeholders. Uncertainties in Environment Agency flood risk maps already existing cannot be eliminated from the results. In case of factors affecting value of properties, flooding is one of the several determinants, therefore the study has to make some assumptions to emphasize the importance of flooding.

1.4 INITIAL RESEARCH STRATEGY

To achieve the aim of the research, an approach of critical evaluation of existing literature to grasp the fundamentals of the current state of knowledge of flood risk on commercial properties and its value was adopted. As the philosophy of research is embedded within quantitative deductive paradigm, a sequential application of literature review, conceptual model generation, data collection from primary and secondary sources followed by appropriate survey of selected areas for model operationalisation was deemed appropriate. Data analysis and interpretation and finally cross validation of the conceptual model is undertaken using another source of data. The overall research methodology is based on the combination of methods and designs to fulfill the pragmatic research philosophy (Creswell, 2009). Incorporating primary and secondary data with help of questionnaire comments, data, experts opinion and textual understanding from literature helped in developing a coherent research design.

In the first stage of research design, concepts of flood vulnerability and property value are examined through exploration of literature. Literature from different disciplines on flood hazard, vulnerability, risk and real estate value with special reference to commercial properties within the developed world were considered. The literature included academic papers, government reports, statements from commercial property stake-holders, publication from valuation office, documents from insurance companies and existing case studies. The theoretical integration of the research helped in construction of a conceptual model for vulnerability of value in commercial property sector towards flooding. However, mere construction of conceptual model would not be adequate for the research aim. Therefore the verification process of conceptual model is undertaken through survey of two study areas using remote questionnaire survey and using responses from commercial property experts.

Both primary and seconday data were then consolidated for model generation and spatial illustration of outputs by use of Geographic Information Systems (GIS). Finally the main research findings by the outputs from the model was illustrated through maps. All in all the contribution of the sequential research design collectively contributed towards attaining the research objectives and hence the

underlying research aim.The approach to the flow of research to reach the goal of obtaining different objectives and finally reaching the main goal has been illustrated by Figure 1.1.

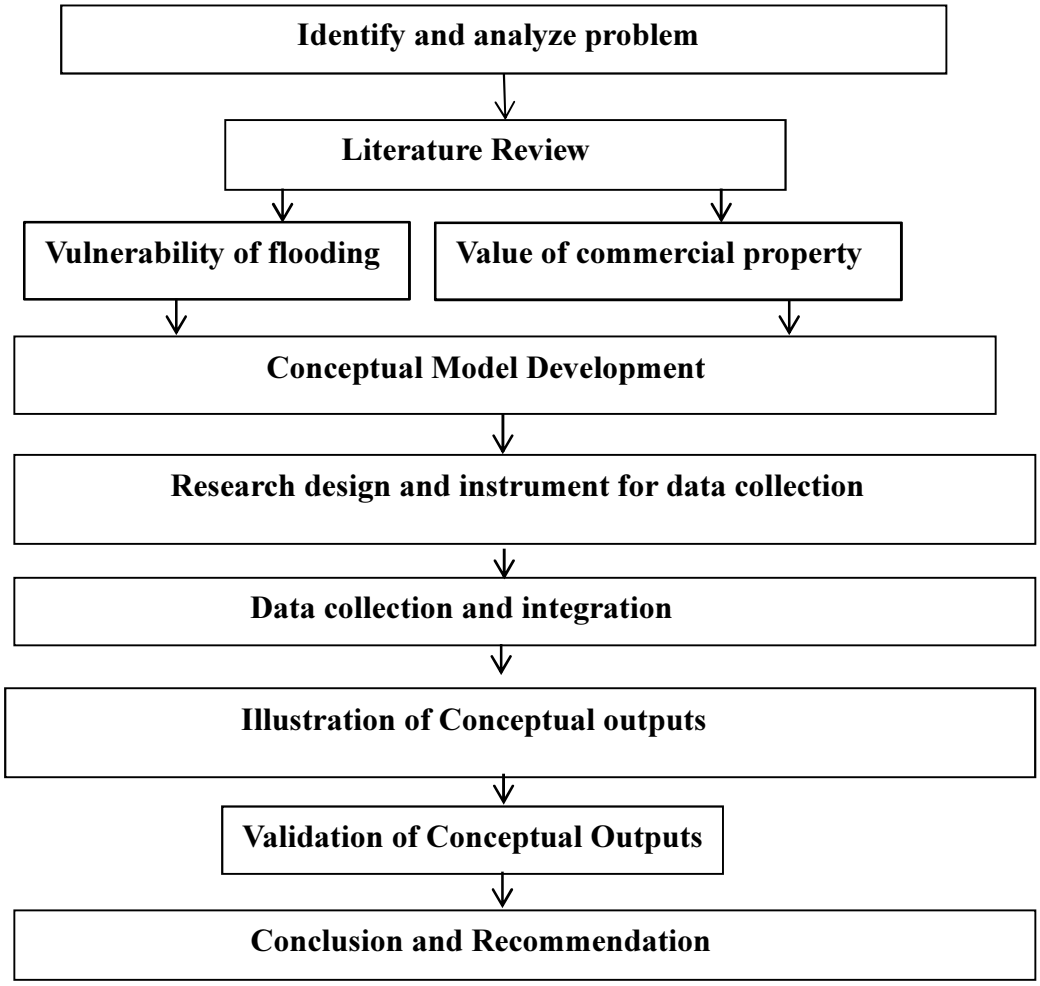


Figure 1.1 Research strategy

1.5 CONTRIBUTION TO KNOWLEDGE

Research related to vulnerability of property value and expected impact of flooding is a much neglected theme in academic research due various limitations in the field of data and methodology. This work is aiming to provide innovative insight through a new perspective revealing the contribution of perception of flood risk and business vulnerability on the value of commercial properties by overcoming those limitations. Since the approach is one of its first kind of study in the field of real estate property research it is a valuable input to the current knowledge base.

The strength of this research lies in the conceptualisation of the subject matter of property value in the context of flood vulnerability. The conceptual model showing the relationship between the various factors responsible for contribution to flood impacts and their implications on business vulnerability and property value provides guidance towards a better conceptual understanding of this relatively neglected sector. This can bring in a new perspective in both property valuation and flood risk management research. An indicative understanding of the perception of commercial property occupiers as one of the outputs of the study in specific sample regions in the UK and spatial vulnerability distribution at post code level will be a helpful tool in flood management activities for future.

The research will have the potential to assist the relevant stakeholders (property holders or owners, buyers or lease holders, local government, insurance companies, investors, occupiers, customers, suppliers, employees, and emergency service holders). The research assisted in developing a methodology which does not depend on available fragmented market data but on data collected from relevant stakeholders and available secondary data. The output from the research will be useful in informing government policy on future vulnerability of properties affected by differential flood risk. Such methodology can help valuers to gain better understanding of the commercial properties where they use subjective knowledge to value properties.

Beyond the direct output, as a result of the research technical papers as academic outputs is published which will further help in dissemination of knowledge in this new but highly relevant field of research. The study will be useful in progression of effort to achieve a safer and less affected commercial property sector towards flooding by bringing relevant understanding in this field.

1.6 PREVIEW OF THE STRUCTURE OF THESIS

The thesis consists of 8 chapters organised in phases as indicated by Figure 1.2. Chapter 1 outlines the context and scope of research and sets out the main aim and objectives. It also describes the research philosophy in brief and identifies the need for research. The preliminary outline of the research strategy and design are described in this chapter in different stages. The main contributions and the

uncertainties that might come across the path of the ongoing research are also presented here.

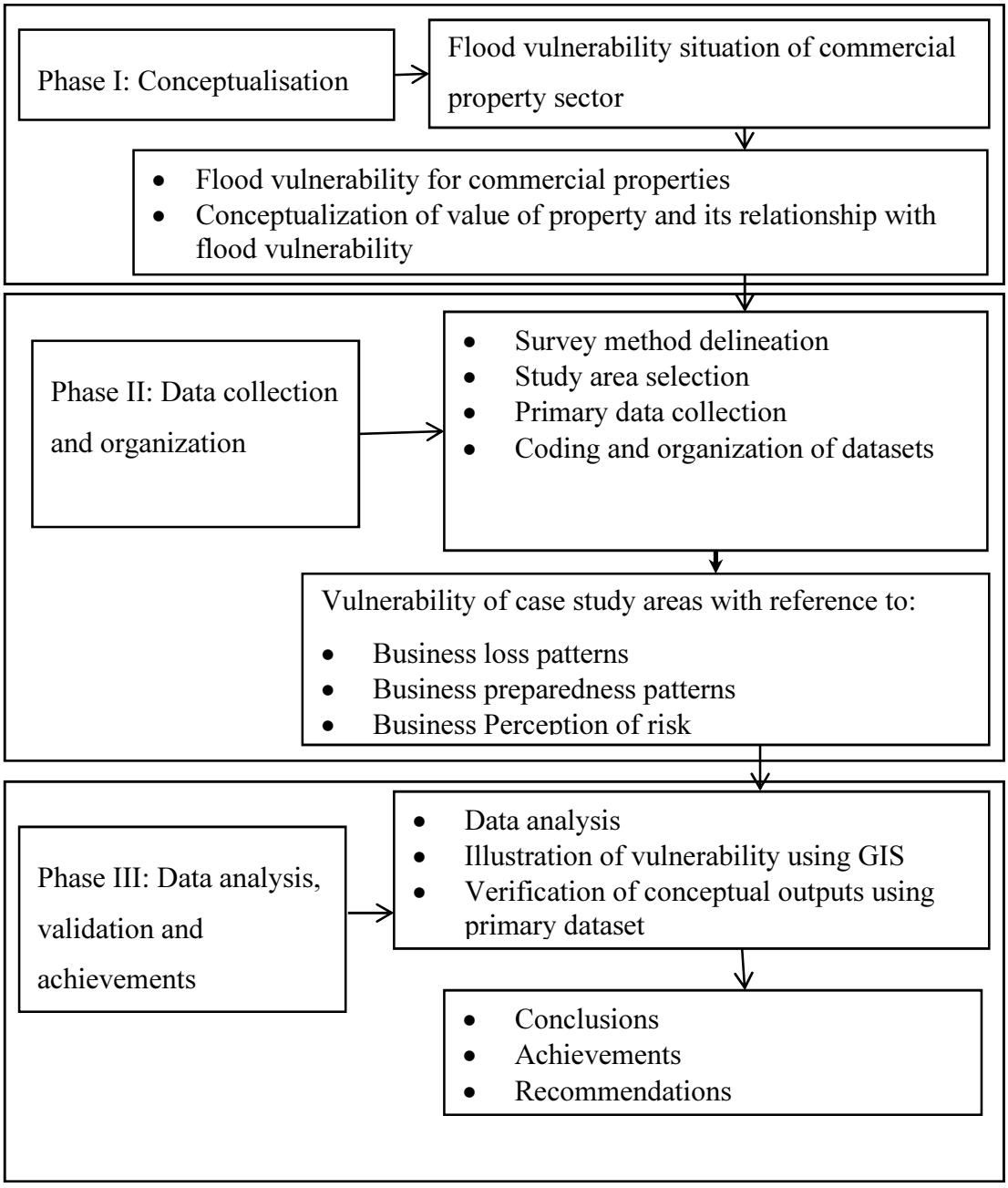


Figure 1.2 Research Process diagram

Chapter 2 provides a brief description of the overall foundation of research which involves the key theme of vulnerability of commercial properties towards flooding. It will also provide the basic definitions used for the vulnerability research and different dimensions and the key themes by means of critical review of existing literature. The chapter will help to develop a better understanding of the scale and

nature of vulnerability of commercial properties to flooding. Furthermore the chapter will seek to highlight various factors affecting vulnerability of commercial properties and identify the nature of flood characteristics. This will help in achieving objective 1.

Chapter 3 will continue with the literature review but will focus on the value aspects in commercial property sector. It will highlight on the variables that affect commercial property value. However, the importance to the factors related to flooding having an effect on property will emphasized more. It will further seek to draw attention to the fact why commercial property sector and its effective impact of flooding is a research sphere that has been neglected for long. Objective 2 will be attained at this stage.

Chapter 4 will focus on the development of the conceptual model based on the literature review in Chapters 2 and 3 fulfilling objective 3. This chapter will present the theoretical model developed signifying systematic and empirical design between the cause and effect relationship among the relevant factors affecting property value. It is important to have a comprehensive consequence of the strength of dependencies between assets, impact parameters, response parameters, recovery parameters and the criticality of the assets in a logical manner.

Chapter 5 will be concentrating on the outline of the methodology that the research is going to undertake. This will involve the justification of the choice of methodology adopted for conceptual model development, arguments involved in the approach and why it is appropriate for this research. This chapter also aids in identifying appropriate methodology, data collection methods and design of instruments along with illustrating the research objectives by empirical design.This satisfies objective 4 of the research.

Chapter 6 and 7 will present the results obtained from empirical exploration of the conceptual outcome through collected primary data using mainly descriptive statistical analysis. Geographic Information System (GIS) will be used for illustration purposes and showing the potential of model outputs in the form of maps. The results will be discussed in detail and interpreted based on the reflections obtained from literature and the collected data. The purpose of the analysis is to identify the factors given that exposure factors of properties and contributing

variables for property value are interrelated. These chapters will achieve objectives 5 and 6. Another part of the exploration process was to verify the outputs using another set of data from the commercial property experts to compare the results from property owners. This will be undertaken by a process of validation of the model outputs. A section will be devoted in describing the methods used for validation of results obtained from the research. This section will accomplish objective 7 of the research.

Chapter 8 which will be the final chapter of the report, will summarise all the findings from the research and highlight the limitations and challenges faced during the process. It will also point out the uncertainties in the results and the potentials for improvement. For the satisfaction of the main research aim, conclusions and recommendations will be drawn based on the findings from the research. This will reflect the work in its various phases and expose the facts by taking into account the collective information obtained during the study. Recommendations will be made for future research in order to practice the most sensible and pre-emptive flood management approach in the system.This will achieve the final objective of the research by concluding from the lessons learnt from the research and with some reccomendations for future researches in this field.

1.7 CHAPTER SUMMARY

The chapter briefly outlined the justification and context of the research. Flood risk is an increasing phenomenon and has been shown as an important issue in the context of the UK commercial property sector. The importance of commercial property sector is immense to the economy and it is highly vulnerable to flood disruption. However within the broad area of flood risk assessment research, the impact on commercial property value is seen to be under-researched. Better understanding of the vulnerability of property value in response to long term implications of flooding can be useful for wide range of stakeholders. Therefore aims and objectives of this research are clearly stated. The scope of the research is discussed together with the identified limitations. The initial research strategy is outlined to address the objectives. This chapter laid the foundation of research based on which the thesis proceeds with detailed discussion in the following chapters. The ongoing research will encompass extensive review of literature, development of

conceptual model, data collection, analysis and interpretation. The following two chapters will commence with contextualising of literature focussed on flood vulnerability and property value.

CHAPTER 2. VULNERABILITY OF COMMERCIAL PROPERTY

2.1 INTRODUCTION

The chapter presents the review of the extant body of literature on vulnerability of commercial property sector towards flooding. The key themes for the literature review are based on the objectives of the study which are structured around the concepts of 'vulnerability of commercial properties' in the context of flooding and 'value of commercial property'. Publications were identified based on key words like likelihood of flooding, damage, resilience, adaptation, recovery, business disruption; market value, risk perception, vulnerability and commercial property value.

The chapter corresponds to the first objective to review the extant body of literature to develop an understanding of the theories, principles and concepts of vulnerability in the context of commercial properties. The chapter commences with a discussion of the concept and delimitation of vulnerability before going onto review this in the context of commercial properties.

2.2 THE CONCEPT AND SCOPE OF VULNERABILITY

In the process of risk assessment, vulnerability has emerged as one of the most critical concepts as an indicative factor of the likely consequence (Vatsa, 2004). Vulnerability is a multidimensional concept and has been studied in various disciplines. This makes it difficult to underpin to a universal measurement (Downing, 2004); nevertheless this dynamic aspect of vulnerability provides an opportunity to ensure that there is a scope to enhance its boundaries to disciplines like property valuation. The current research emphasises that multiple stresses and pathways of vulnerability can contribute to significant understanding of social and institutional dynamics of a socio-ecological system (Adger, 2006). A number of researches from various fields in vulnerability studies have identified the type and nature of vulnerability in an integrated manner (Cutter *et al.*, 2008; Adger, 2006; Tierney & Webb, 2001; Bhattacharya & Lamond, 2011).

The prerequisite consideration of disaster risk management studies is understanding of nature of vulnerability of the elements at risk (Moser, 2010; Adger, 2003; Lorenzoni *et al.*, 2000a) which in this case is the commercial property sector. Research on vulnerability from different disciplines significantly improved the understanding of the structure and functions of human-environment conditions and directed this research towards questions such as: who and what are vulnerable to the multiple changes in human and environmental aspects? Do the actions of humans change the level of vulnerability? What can be done to reduce the level of vulnerability? The answers to these questions lies in the working of the coupled human-environment system (Turner *et al.*, 2003b, 2003a). Here the analytical unit of commercial property system is a "human environment system" which can be defined as "a system which includes both societal (human) and natural subsystem in mutual interaction" (Gallopı´n, 2006).

The scale of this system can be from local community with its surrounding natural environment or the global system. In the context of the present research, the system is represented by the commercial properties dealing in businesses of different types and interacting with their surrounding natural environment by coping with stress such as floods. To establish such a system it is important to understand the simultaneous interaction of both socio-economic and natural components of the unit and how the interaction between different components makes it vulnerable towards a certain stress. For instance, damage of commercial properties due to flooding is greatly associated with continuous interaction between natural and human systems. The effect of physical and economic damage caused during flood events can be attributed to the performance of focal factors which can affect property value in the long term. The damage caused by flooding can either be direct physical impact caused by flood water (Kappes, Papathoma-Köhle & Keiler, 2012; Kelman & Spence, 2004), or indirect effect on the continuity and performance of business, incurring loss by taking time to recover from its disrupted state of operation (Alesch, Holly & Nagy, 1998; Gissing, 2002; Parker, 2009; Tierney, 2007).

The rationale behind measuring vulnerability is reducing disaster risk; however, this requires better understanding of exactly what are the various components of vulnerability that determines risk. The analytical unit being the

commercial property sector involved in business activities which are interacting with its natural environment, different aspects of vulnerability both from the environmental risk side and the human side become relevant here. The vulnerability components are often overlapping in nature and contribute to the scale of impact on total vulnerability. The interaction between different dimensions of vulnerability is bounded spatially and temporally (Turner *et al.*, 2003a; Polsky, Neff & Yarnal, 2007). This research concerns the vulnerability of commercial property values with reference to flooding. Since the concepts have been used in many fields it makes the definition of focus of the present research – the system of commercial property sector- easier and offers a strong justification why this is important for both vulnerability and valuation research. Before reviewing in detail the state of vulnerability of commercial properties towards flooding it is important to develop a better understanding of the key definitions of the basic terminologies related to vulnerability used by different related disciplines.

2.3 DEFINING BASIC TERMINOLOGY

Vulnerability is a powerful analytical tool for describing different stages of susceptibility, to harm, powerlessness and marginality of both physical and social systems and guides the normative flow of action to enhance welfare through risk reduction (Adger, 2006). There are several definitions of vulnerability from divergent disciplines and themes. The differences are mainly based on their tendency to focus on different components of risk, responses and outcomes from them. For instance, the focus of environmental literature is ecology based, where vulnerability relates to species and ecosystems to damage. For species it is "vulnerable to extinction" and for ecosystems it is "vulnerable to irreversible damage" (Alwang *et al.*, 2001). Vulnerability here is more focussed on the outcome of activities or changes in system and processes rather than a constant process which is the case for human centric research.

The World Bank has divided vulnerability into two major dimensions: hazard exposure and capacity to cope. With higher capacity to cope the level of vulnerability is lower and vice versa (Sharma *et al.*, 2000). This is similar to many other disciplines where response towards hazards is taken as the most important indicator for understanding vulnerability.

In disaster management the focus of vulnerability is mainly in understanding the relationship between the human and natural environment. The theme mainly includes people, households, businesses, communities and the damage faced by them as a result of natural hazards. Broadly vulnerability in disaster research can be generalized as the potential "degree of loss" from hazard events (Timmerman, 1981). The concept of dual systems incorporating sensitivity, resilience and exposure to hazard is quite popular in several research publications (Thywissen, 2006; Turner *et al.*, 2003a, 2003b; Polsky, Neff & Yarnal, 2007). Multitude of components and forward looking variables are exposed as the intrinsic feature of the community indicating a damage potential (Thywissen, 2006; Wisner *et al.*, 2003).The literature considers that everyone is vulnerable, some more vulnerable than others due to their situations and choices. The elements at risk and their responsiveness are recognised based on their access to assets and opportunities and level of resilience over time (Wisner *et al.*, 2003; Vatsa, 2004). The definition of vulnerability constitutes an underlying condition which is distinguished from the risk events, that triggers the outcome.

Disciplines like economics, sociology, anthropology, and health science consider vulnerability slightly differently. Economics as a discipline focuses on variability in price or value of assets with response to changing risk. Although it is quite implicit that in economics the conceptualisation of vulnerability is embedded as the combination of risk and level of response, the term vulnerability is generally avoided (Kanbur & Squire, 1999). There are several examples in poverty literature that emphasises the explicit risk source but fails to identify the response mechanism and the outcome remains being "in" and "out" of the state of poverty. However, some promising studies recognize vulnerability as an "ex-ante" and "forward looking probabilistic measure" (Mansuri & Healy, 2000; Pritchitt, Suryahadi & Sumarto, 2000). While identifying vulnerability of households in response to income and consumption changes the definition given was "vulnerability is a broad concept, encompassing not only income vulnerability but also those related to health, those resulting from violence, or social exclusion- all of which can have dramatic effects on households" [(Coudouel & Hentschel, 2000) pg.34]. Vulnerability has many facets and measuring income is only one of the many factors associated in affecting

its level. In case of present research the idea of including flood as one of the many aspects of vulnerability of commercial properties can be associated with this concept.

Research including asset based approaches mostly considers implicit risk; sometimes including value of assets, fails to describe adjustment response mechanisms. The asset based research does not exclusively fall within economics, and is multidisciplinary in nature. There are important contributions from anthropology and sociology, and environmental science, (Moser, 1998; Bebbington, 1999; Reardon & Vosti, 1995).The importance of assets in terms of managing risks in asset based literature are given adequate prominence in terms of reducing vulnerability; however how far the assets are effective in reducing vulnerability is not established empirically. It is however established that level of vulnerability depends upon the level of available assets. Vulnerability, therefore, is closely related to asset ownership: the more assets people have, the less vulnerable they are; the greater the erosion of assets, the greater the level of insecurity' (Moser & Holland, 1997).

Despite the differential view of the concept of vulnerability in different disciplines this could be noticed that hazard based research has been questioned in current disaster literature and vulnerability concept has been introduced to capture the inter-linkage between social-economic and natural systems in a better manner (McKintire Crocker, G. C., Peters , E., 2010).The agreement seem to have found its way based on factors related to *liabilities* and *capabilities* and that it has *physical and social elements.* Keeping in mind the diversified and tautological nature of vulnerability definitions, most literature are based on some version of the following relationship:

Vulnerability = [Exposure X Susceptibility)/ Resilience] (Penning-Rowsell & Chatterton, 1977)

The equation has exposure and susceptibility in the numerator due to their effect on increasing the level of vulnerability, with resilience factors decreasing vulnerability in the denominator (Balica & Wright, 2009). It is however important to define the terms like exposure, susceptibility and resilience at this point. The concept of exposure points towards the diverse elements at risk (goods, infrastructures,

hydrological indicators, people, properties and so on) can be understood by the values that are present in the areas susceptible to disaster (Messner & Meyer, 2005). Susceptibility is described as the relative damageability of the property and materials during disaster occurrence directly or indirectly, which relates to the inherent characteristics of the element at risk (Penning-Rowsell & Chatterton, 1977). The term resilience indicates the capacity of a potentially exposed system to cope, recover and adapt in order to maintain or achieve an acceptable level of functioning (UNISDR, 2004).

The flood system which acts on the commercial properties, influences the physical and socio-economic processes interacting within a wider system. The physical systems are characterised by the processes of rainfall and snow melt which can lead to fluvial flooding, over flow of drains, runoff overload, and groundwater flooding or flooding of coastal lowlands. The response systems such as artificial flood defences, property level defences and storage of water are intended to reduce the effect of flood water on properties and control inundation (Hall *et al.*, 2003). The impact of flooding on assets is determined by the capacity of the flood control measures and individual mitigation measures undertaken by the individual or the organisations. The decision to take up mitigation measures often is determined by organisations' risk perception. The Pressure- State- Impact- Response model (Turner *et al.*, 1998) deals in such changes in the state of a system and its response to the fluctuations. A more recent and well established conceptualisation of this approach is reflected in Source-Pathway-Receptor model (DETR, 2000) both directly and indirectly to the system state. From the definitions and usage of vulnerability in different fields and their importance to the context of this study established from the above discussion it is established that influencing factors for identifying vulnerability of commercial properties is dependent on the interaction between the factors within its system state. However, it is now essential to understand how the commercial properties behave as a system and the different entities within the system that affect their level of vulnerability.

2.4 THE HUMAN-ENVIRONMENT SYSTEM

The concept of vulnerability depends greatly on the research area and mostly exclusive to the societal subsystem it is applied to. Therefore, due to the multi-

dimensional and dynamic nature of the problem, to conceptualize the main aspect of vulnerability and integrate the conceptual relationships between multiple factors, a generic systems approach is appropriate (Clayton & Radcliff, 1997; Gallopı´n, 2006). This assumes that vulnerability constitutes components which include exposure to external stresses, susceptibility to perturbations and capacity to adapt (Adger, 2006).

2.4.1 The systems theory

This study is based on the holistic thinking emerged by the systems theory. In researches such as this understanding the manmade environment as an interacting part of its outside physical environment requires interaction from multiple perspectives (Skyttner, 2002). It is a highly cross scientific occupation where synthesis is a pre-requisite. The theory depends on the concept of expansion of focus of observer often called 'expansionism' where rather than concentrating on static and structural properties the observer concentrates on function and behaviour of whole society in the form of explanation and understanding (Pidd, 2009).

This theory assumes that every aspect of the universe is not independently working but they belong to one universal system of organic pattern. Here is an attempt to bring together fragments of research findings to obtain a comprehensive view of human, nature and society (Skyttner, 2002). The Law of requisite variety proposed in the famous book of cybernetics is very relevant in the context of this research, where it was emphasized that a system will be able to recover from external stresses to an extent that is equal to its response capacity (Ashby, 1956). This informs that the more robust the composition of the system response, the better is its strategy for resilience and capacity to recover post external environmental stresses (Alesch, Holly & Nagy, 2001a).

A system is defined as "anything that is composed of system elements connected in a characteristics system structure" (Bossel, 2007). The way the system elements are configured determines how the system will perform specific functions within its specific environment. The function within the system attributes to the purpose of the system and it works within the system boundaries. However, the system boundary is permeable if the system is open to interact with its adjoining environment. The basic system concepts are illustrated in Figure 2.1. Basically,

systems theory allows us to deal with the general properties of a system regardless of its form or domain whether it is conceptual, concrete or man-made. The main goal of systems theory is to build generalized theories of dynamism within a system, to work out a methodological way of describing the functioning of the system, and finally to model the system in a way that it is close to reality.

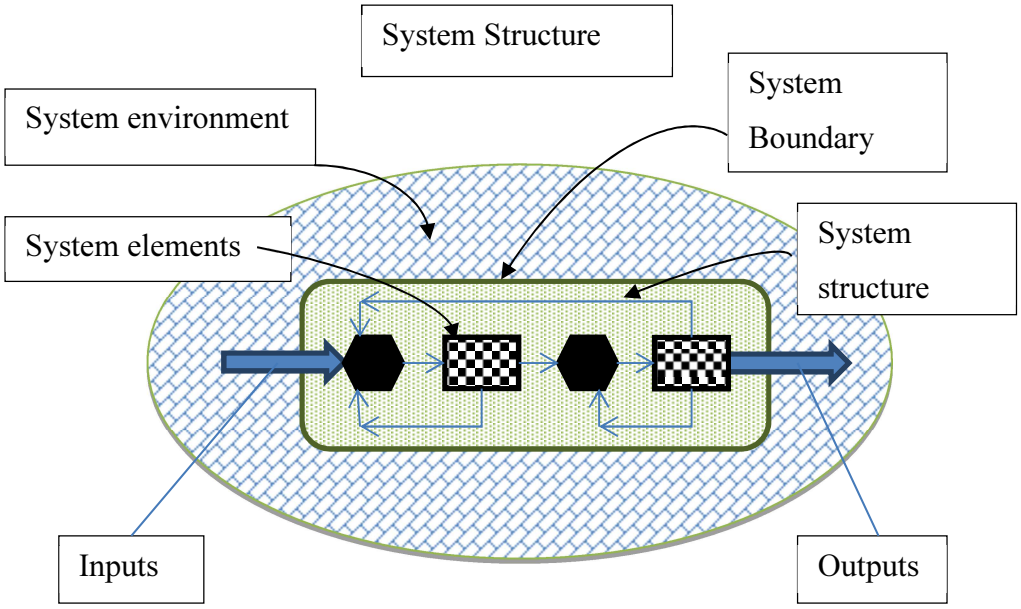


Figure 2.1 System Concepts [adapted from (Bossel, 2007)]

The application of the systems theory works in an integrated manner so that no important factor within the structure is neglected in terms of problem solving through constructing, optimising and controlling by taking into account multiple perspectives (Skyttner, 2002; Pidd, 2009). This theory fits particularly well within the context of this research where the dynamics within the commercial property can be associated with a system which is interacting with external environmental factors.

2.4.2 The commercial property system

A system such as commercial property can be disturbed by certain components and may not be disturbed by others. Therefore measurement of the components of exposure from different dimensions to multiple disturbances is required to understand the concept (Gallopı´n, 2006; Turner *et al.*, 2003a). The potential of a system to change when confronted by a disturbance like a natural disaster not always comes as a response but also as a precaution from the

confrontation. This is where the ex-ante adaptive or resilience measures comes along.

Entities like commercial properties are pre-disposed to perform certain functions to attain specific purposes. Much like other human centric systems it is a dynamic system with antecedent static factors within the system structure. There are dynamic processes within the system boundary which involve activities. For instance the organizational structure within the system process is dynamic in nature. These processes within the system are a co-ordinated set of activities which are interconnected to achieve common goals. The system environment consists of the factors or other systems that influences the behaviour or working of the system. Dynamic systems change with time and have very little influence from within the system.

If the system of commercial property is compared to the above mentioned system structure it can be seen that the inputs of system are the internal factors located within the system of commercial property sector. These inputs can be the entrepreneurial managerial attitudes, businesses' inclination to satisfy financial needs, professional management and planning and control systems (Ball, Lizieri & MacGregor, 1998). There can be one or many sub-systems which can influence the activities of the system from within. The interaction of system elements within the system structure and boundary can affect the outputs of the system to sustain its functions. The external business associated factors affecting the system can be related with external systems like other business competitors, customers, financial institutions attached with the funds of the company and so on.

The perception of the firm related to the external factors is the main key factor that links the two systems together. The system of commercial property organizations falls within the boundary of self-sustaining systems which are characterised by the ability to sustain itself in its environment. This means, it has "adaptability" capacity to change its rigid system structure, bring in changes and co-evolve with its surrounding environment (Bossel, 2007). The uniqueness in such system is their ability to be flexible and adaptive changes to known and unknown challenges. Challenges within the system or inherent risk can be the result of

mismanagement or uncertain decision making. This is the outcome of probability of failure and the cost of such action.

Natural disasters like floods are a type of risk external to the system. The effect of a natural disaster on the system depends upon the nature and characteristics of the exposure and its probability of occurrence. Risk is associated with both; system as a whole and the processes within the system. The system exposed to external risk such as flooding is part of the system environment which encompasses all the physical and organisational sub-systems influenced by flooding. As a dynamic system, the commercial properties have the capacity to change in time by responding to existing and probable challenges. The fundamental mechanism lies in the external and internal feedback of cause and effect relationship between the factors influencing the system under investigation (Ranganath & Rodrigues, 2008). The causal relationship of the feedback system can indicate that the drivers or the processes that change the state of the system are responsible for bringing in perturbations which subsequently affects the risk in multiple dimensions (Polsky, Neff & Yarnal, 2007). The measure of risk is determined by systems vulnerability and adaptive capacity to cope with the changing system state. Now the question arises what makes the systems vulnerable to the differential flood risk situations? The following sections illustrate the various dimensions of vulnerability of commercial properties towards risk of flooding and identify the major influencing factors affecting vulnerability.

2.4.3 Types of vulnerability

The effect of flooding on commercial properties could be both direct and indirect. Both aspects of vulnerability sources are important for estimating and analysing total vulnerability inherent in commercial property systems. Disasters disrupts businesses in a variety of mechanisms and force them to either wait for the reinstatement or close down for a period of time. Such disruption of businesses especially for small and medium industries can have severe effects and put competitive pressure from other businesses (Zhang, Lindell & Prater, 2009). Research on business vulnerability emphasise that loss in business sector due to disturbances of extreme events like flooding can be well explained and described largely by understanding vulnerability factors. It is not sufficient to only concentrate on physical damage or mitigation and preparedness seperately but to focus on the

system as a whole (Chang & Falit-Baiamonte, 2002). A system can be vulnerable to environmental changes either directly or indirectly. The following section describes the different aspects of direct and indirect vulnerabilities.

2.4.4 Direct and indirect vulnerability within commercial property system

Direct vulnerability relate to physical damage and limited access to business assets during a flood. Typically, enterprises with large fixed assets like buildings, equipment, furnishings, large inventories such as raw materials, intermediate products and finished products are more vulnerable to direct physical damage. Damage to infrastructures ,fittings and buildings, loss of stocks due to lack of mobility, are also affects of direct vulnerability (Tierney, 1997; Zhang, Lindell & Prater, 2009). Extensive study on the "flood actions" indicate how through different physical processes like water forces, pressure, energy transfers, and consequences of contaminant water have impact on damage potential (Kelman & Spence, 2004).

A property's exposure to direct physical damage influences the total vulnerability. When businesses suffer from various forms of physical damages such as structural, non-structural, furnishings, inventories, equipments, business records and lifelines, it can be directly correlated with the total loss suffered by business (Chang & Falit-Baiamonte, 2002). Depending on the value of physical structures or economic assets exposed to loss the potential cost of damage can be estimated providing a firm idea of the level of direct vulnerability. However, properties with higher dealings in cash and soft business securities are safer in terms of physical vulnerability since they are intangible in nature and can be safely stored in separate locations (Zhang, Lindell & Prater, 2009). Lost documents and records are important physical losses which can cause post event recovery work to delay.

Physical damage is one of the many factors influencing loss of business. Many items of flood damage loss are the function of nature and extent of flooding (Penning-Rowsell *et al.*, 2010). These damages and losses can disrupt network and social activities causing indirect losses. Indirect losses ripple out from direct losses (Committee on Assessing the Costs of Natural Disasters, 1999). Therefore, even if business escapes direct damage it may be forced to close as a result of indirect

impacts such as disruption in supply chain, access problem to employers and employees, loss of customers and so on (Tierney, 2007).

Business interuption costs can often be more notable than direct damage of flooding. The broad sources that enable businesses to perform various primary and secondary value activities composes their value chain (Zhang, Lindell & Prater, 2009). The value chain includes product and processes (for example, operations, sales and marketing, purchasing, research and development) and supervision and general administration of processes (Thompson & Strickland, 1996). In order to understand indirect vulnerability, knowledge of working of the commercial sector is very important to analyse the effect flooding on its processes. Figure 2.2.illustrates a simplified flow model of how businesses operate in market [adopted from (Zhang, Lindell & Prater, 2009)].

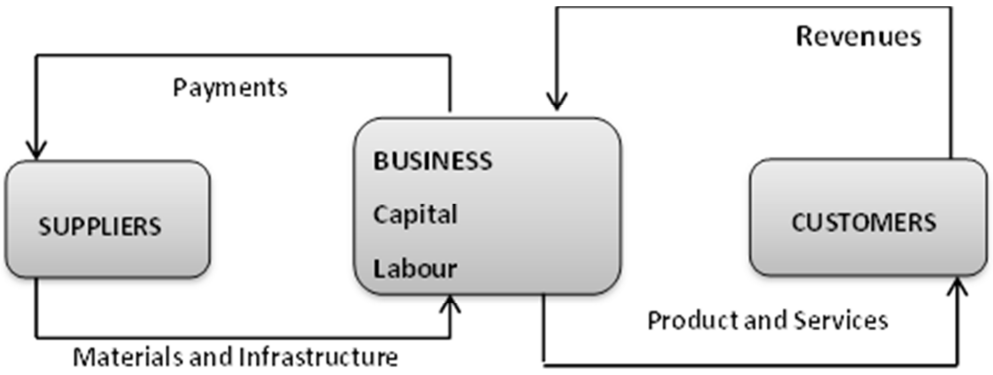


Figure 2.2 Flow model of working of businesses in commercial property sector [adapted from Zhang et al, (2009)]

There is direct link between suppliers, producers and consumers within the market. There might be temporary closure affecting revenue generation for the commercial property on a localized level but the business can easily recover with a working action plan and existing suppliers and market outside the impact zone. This may have adverse effect on those business enterprises which are not directly affected by the flood but their suppliers or consumers are within the zone of risk.The efficiency of well managed business often lies in its tightly integrated structure.

Sometimes failure of one element can cause further indirect consequences on continuity of business. In other words "the domino effect" or ripple effect on operations of the production has a multiplier effect over indirect losses (Zhang, Lindell & Prater, 2009). This is an indirect effect of flooding that might make a property vulnerable and imbalance the dynamic equilibrium of the market even when not under direct impact of flooding. To this point, it is expected that businesses having a diverse area of sale and supply have better chances of surviving from flood disruption than those concentrated to local areas. This makes businesses with a neighbourhood customer circle economically less vulnerable than larger enterprises.

Flooding in Warwickshire in 2007 was reported to have such impact on five of its market towns with 200 businesses flooded most of which were small and medium in size (Savage, 2007). Similar study in Chesil Sea defence Scheme also showed that in specific circumstances indirect effects can be highly significant (Penning-Rowsell & Parker, 1987). A simple diagram describing how rippling effect of flooding can affect suppliers and customers of an affected producer can clarify the issue better (see Figure 2.3).

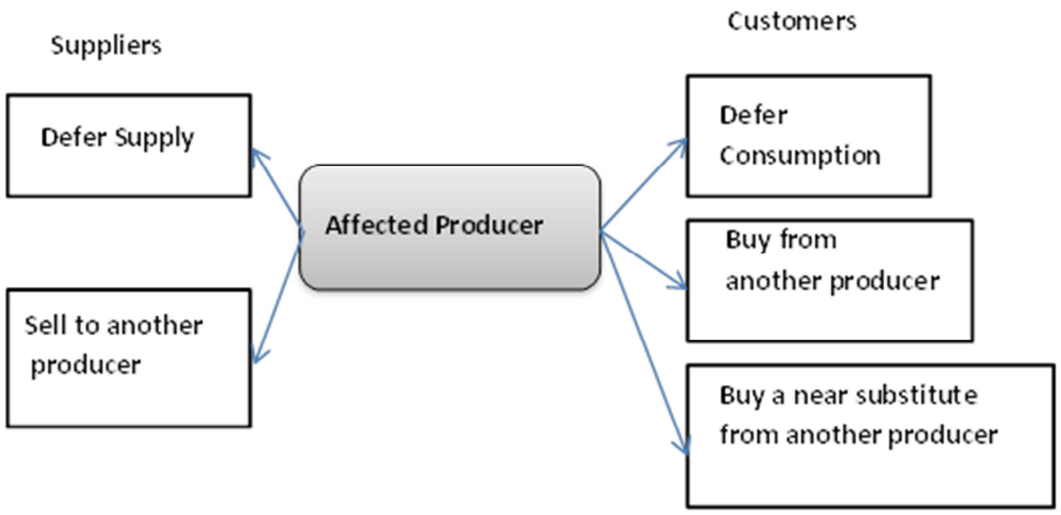


Figure 2.3 Options for customers and suppliers of an affected producer [adapted from (Floodsite, 2007)]

Nature of ownership of capital in businesses can also be aggravated by indirect impact of disasters and affect level of vulnerability. For instance the value of return from interest depends on whether the property is leased or owned. Therefore

businesses with higher leased capital investments will suffer from more pressure than these having smaller window of leased property (Alesch, Holly & Nagy, 2001b). Similarly, temporary or permanent relocation of employees due to injuries, death or illness during or in a situation of long term post–disaster recovery acts as a major factor in turnover of total number of working population. An enterprise will succeed in faster recovery if it is efficient in employer replacement (Tierney, 1997; Quarantelli, 1982).

Another issue which affects indirect vulnerability is the disruption in accessibility to workplace. For instance, damage to transport links, closed roads, slow moving and diverted traffic can delay in business mobility and keep businesses from recovering soon. During the 2009 Cumbria flood in UK Southwaite footbridge in Cockermouth and nearby Lorton Bridge were destroyed by floods, along with Northside Bridge in Workington thus causing huge disruption in normal flow of transportation for days (Telegraph, 2009). It is however possible for some sectors like finance, real estate and insurance to let their employees work remotely with flexible hours during disaster recovery phase, nevertheless sectors like manufacturing and construction are helpless in such situation (Kroll *et al.*, 1990). Further interruptions corresponding to supply of power, water, telecommunication, and fuel after flooding is another post-impact effect which might cause indirect effects on disruption to business continuity enhancing vulnerability.

The next type of indirect effect commercial properties can have is losing customers for business. Some authors explained it as the casualty or relocation from the affected area destroying the existing customer base. (Smith & Wyatt, 1996; Ingirige & Wedawatta, 2011). This in turn has greater impact on small enterprises like whole sale and retail firms rather than large ones with national and international customer connections, bringing them to a situation of regaining customers to cope with the demand and supply chain to maintain profitability exposing them to higher level of vulnerability especially if the market is within the impact affected zone (Alesch, Holly & Nagy, 2001a; Webb, Tierney & Dahlhamer, 2002, 1999).Over-dependence on other business supplies, problems of getting finance from financing agents and getting back the claims from insurance companies can be key issues which are covered under vulnerability from suppliers. The level of vulnerability

offcourse varies among commercial enterprises based on their level of preparedness and response rate.

The four pillars of commercial sector are capital, labour, supplier and consumers. Any disruption in this chain of event can bring discontinuity in business and as a result make it vulnerable to potential business viability. Capital includes fixed assets and inventories, cash and securities while labour includes population that help business properties to run its usual production and supply. Suppliers are responsible for running the lifeline of business operation; for example water, electricity, telecommunication and transportation affect significantly in running the supply side of the businesses. The customers, whose role is to generate revenue to continue businesses to make profit. Based on the above review of different literature a mental model is derived which describes the working of commercial business property sector and the directional flow of different dimensions of indirect vulnerability from post-disaster impacts in Figure 2.4. Different aspects of the specific groups and subgroups of the four pillars of commercial property sector are shown in the figure. The directional effects on the level of vulnerability are shown with arrows indicating the direction of impact, that is., positive or negative impact. For captial the most important aspects are size, mobility and ownership of property. If disrupted they all have increasing effect on the level of vulnerability.

Similarly, two most prominent factors affecting vulnerability of businesses are flexibility of the organisation to let their labour force work from safer places or ability to cope with the disruption caused by labour reduction and making arrangement for replacement will be beneficial in a way that will reduce vulnerability. Coming to the third aspect of supplier, as mentioned before continuity of essential services are important to reduce level of vulnerability. If situation arises where the enterprises are dependent on other businesses and those areas are flooded, the level of vulenrability can increase substantially.

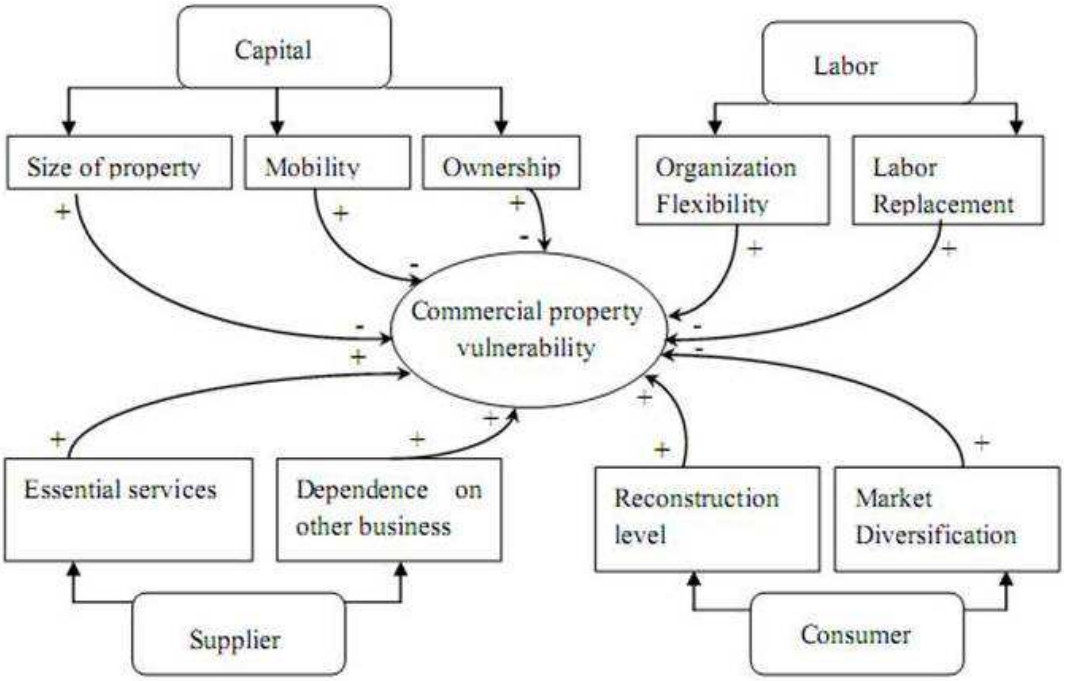


Figure 2.4 Conceptualization of value chain basis vulnerability of commercial properties (Bhattacharya, 2011)

The final mainstay of commercial property sector are the consumers. Loss of consumer base by businesses can lead to adverse results unless the enterprises are ready to invest on bringing their consumers back. The level of reconstruction is definitely one of the primary aspects in that regard. Businesses need to create their predisaster competency to keep their consumers intact and for this purpose diversification of market could be helpful, so that if one market fall short the other can pick up.The more diversified the market is , the better for the business property to survive the loss of consumers. These factors need further consideration for improvement of resilience to flood impacts. The response of commercial properties again reflects towards perception of the elements at risk towards certain magnitude and frequency of risk. These findings imply that classification of vulnerability based on the broad window of direct and indirect vulnerability contains a large number of subfactors from different dimensions. These dimensions can be physical or natural sources, economic , social or environmental triggers that can be generated as a result of risk of flooding.

2.5 TRIGGERS FOR VULNERABILITY TOWARDS FLOODING

Several schools of thoughts define vulnerability in their specific contexts and the outcome of direct and indirect effects of vulnerability on businesses. However as mentioned before, there are several indicators that affect vulnerability of properties towards flooding (such as amount of exposure, type of assets exposed to certain level of exposure and their level of susceptibility) directly or indirectly. A conceptual framework which gathers the understanding in one context proposed by Hahn (2003) is showed in Figure 2.5.

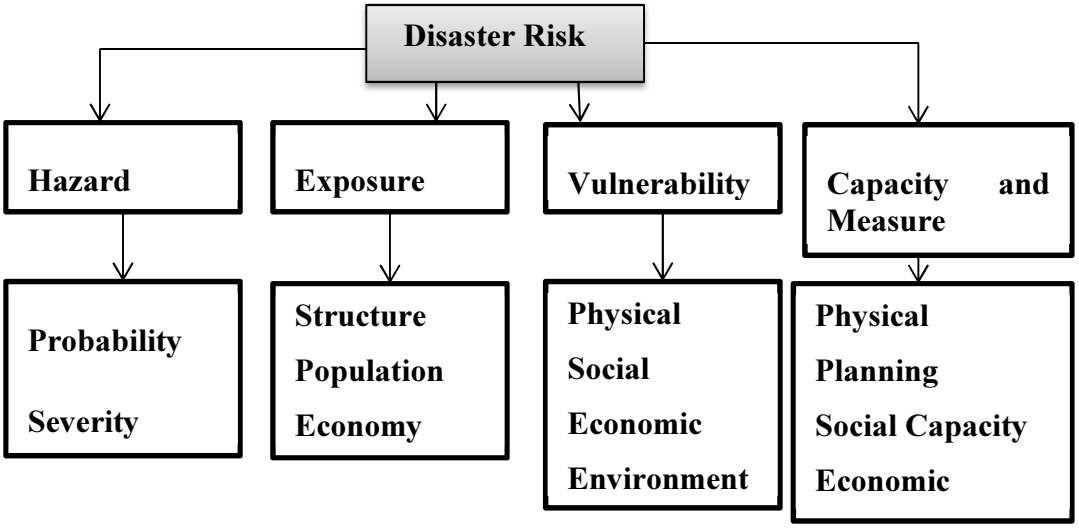


Figure 2.5 Rational for choice of indicators adapted from (Hahn, Villagrán De León & Hidajat, 2003)

The type of vulnerability included in this framework allows the research to include vulnerability indicators from all possible dimensions thus providing a broad scope for exploration.The following discussion will provide an explanation of the different dimensions of physical, social and environmental vulnerability within the scope of this research. The fourth dimension of economic vulnerability, is discussed in Chapter 3 to better understand vulnerability of value.

2.5.1 Physical vulnerability factors

The physical vulnerability of property addresses the effects of interaction between damaging agent (flood in this case) and the physical environment. It is defined as the "degree of loss or damage to a given element or a set of elements within an area affected by hazard" (ISSMGE:Technical Committee on risk

assessment and management, 2004). Physical vulnerability is normally measured by fragility or depth-damage curves which link the intensity of hazard to the expected damage or cost of damage related to total value of risk (Kappes, Papathoma-Köhle & Keiler, 2012).

The concept of physical vulnerability within the focus of this research deals with exposure factors leading to physical damage, susceptibility and resilience characteristics of commercial properties. The vulnerability of property towards physical flood damage largely depend on the total value of exposed resources to certain characteristics of flooding (Messner & Meyer, 2005). The characteristics include type of flooding, their magnitude and frequency as well as persistence of flood event influencing level of exposure of the property towards damage (Hall *et al.*, 2003; Reynard, Prudhomme & Crooks, 2001). The assets that are located within flood plains are likely to be at significant risk of being in range of most vulnerable. Factors like characteristics of construction and the level of preparedness of the occupants or owners of the property help in increasing or decreasing the level of their response capacity. Preparedness level reflects the vulnerability intensity of the property at risk. Many researchers indicated that adopting resilience measures can affect the level of physical vulnerability (Clark, 1998; Gallopı´n, 2006; Ingirige, Jones & Proverbs, 2010; Lamond, Proverbs & Hammond, 2009). Direct impact of flooding can also be affected by indirect factors. One important factor worth mentioning is changing nature of climate. The following sections will elaborate on different factors that affect physical vulnerability of property.

2.5.1.1 Effect of climate change

The increased frequency of flooding and the consequent damage has been observed worldwide (Doornkamp, 1998; Schreider, Smith & Jakeman, 2000; Hall *et al.*, 2003). UK businesses reported (64%) that they have experienced major or minor disruption as a result of extreme weather changes in their productivity or sale (UKCIP, 2010). The level of adaptation of businesses to cope with the changing weather condition is not appropriate to combat anticipated future, therefore even if the evidence for changing climate and its effect on businesses is not direct, it is highly relevant for understanding of vulnerability to climate change and help to inform efforts to adapt to future climate change.

Changes in weather and impact of extreme weather events can have effect on business logistics such as utilities, transport arrangements and supply chains. Such situation is a threat to business continuity and makes businesses vulnerable especially for those which are relying on one source of supply or have smaller options to alternatives (Berkhout, Hertin & Arnell, 2004). In essence, business finances may get affected as a result of cost of damage, loss of sales or disruption due to impact from extreme weather event. The effect on insurance premiums and lack of access to finance from lenders as a result of high risk status might eventually have larger impacts on business properties with less adaptive capacity.Over the past 40 years there are frequent spells of wet weather and increase in total precipitation in the UK (Osborn & Maraun, 2008). Among the top five wettest years in the UK 4 of them are within the last 15 years (Met Office, 2012).The 2007, 2009, 2010, 2012, 2013 and 2014 flood events in the UK were all partly because of the extreme rate of rainfall in a very short period of time. Climate change is considered as a factor for predicting future changes in flood risk. However, due to the large uncertainty in predictions the level of impact cannot be ascertained.Therefore, factoring climate change on its own is not within the scope of this study although it is inherent part to the system.

2.5.1.2 Event characteristics

Physical vulnerability of flooding and designing solutions and measures for limiting its effects is associated with the nature and different characteristics of flooding. Event characteristic namely, type, magnitude, frequency and duration of are the main factors affecting physical vulnerability.

Type indicates the source of flooding, such as river or fluvial sources, pluvial or overland flooding, coastal, groundwater, flash floods, or caused by failure of artificial systems. Magnitude of flooding affects physical vulnerability immensely (Kenney *et al.*, 2006). If the event is small and the potential coping capacity is sufficient then the level of vulnerability is lower. However, when the magnitude of flooding is higher than the level of preparedness, such as the unexpected 2007 flood event in the UK, the level of damage and disruption is much higher than anticipated (Marsh *et al.*, 2007; Pitt, 2008). Historical data are important sources of gaining knowledge of flood magnitude, however, they are not representative of rarer events.

Similarly, magnitude of an event for particular return period can change significantly (Dinicola, 1996). A sound understanding of the likelihood of occurrence of flooding or flood frequency is one of the fundamental steps of understanding flood risk. Although to fully understand risk the degree of exposure and the nature of exposed items are also important, as well as the immense uncertainty in determining the flood frequency. Nevertheless, with understanding of flood frequency people can comprehend and different options of preparedness and risk reduction can be evaluated by decision makers (Jha *et al.*, 2012). Flood duration is another factor that can have adverse effect on the structural aspect of building. If flooding is for longer duration the contact with water can cause severe disruption inside and outside of the structure and determine the level of damage (Nicholas, Holt & Proverbs, 2001).Contact with water can cause scour and erosion in building materials causing collapse. Therefore duration of flood event affects magnitude of impact.

2.5.1.3 Topography

The topography (height and slope) of land and situation of buildings often determine the route and flow of water during flood. Water flow, velocity, depth, stagnation, rate of rise, load carried and deposited with water are all interdependent partly to topography of land. Therefore direct damage caused by contact with water due to variation of topography is important for determining flood risk.

Velocity of water can cause irreparable damage to the structure of building and cause destruction of properties (Samwinga, Proverbs & Homan, 2004; Kelman & Spence, 2004). Moving water depemding on its speed can cause differential damage to the structural integrity of buildings. Higher slope can lead to increased velocity of water resulting in flash flood leaving very little time for removing valuables to safer locations. Also low lying lands suffer from stagnation of water and can take days to subside.

The depth of water is the most used factor in analysis of physical vulnerability by means of depth-damage curves (Molinari & Handmer, 2011; Penning-Rowsell *et al.*, 2010). This is a factor of high relevance and relatively predictable unit. The pressure difference of water depth between inside and outside of buildings can cause considerable destruction to the structure and inventories

(Kelman & Spence, 2004). Normally water depths are documented for damage estimation immedeately after flood event. Many studies have convincingly demonstated that with increased depth of water the damage also increases (Gissing & Blong, 2004).

The effects of sediment load carried by river water and then by the overland flood water is a major cause of physical vulnerability. Adverse impacts can be caused downstream as sediment load travel with water and hit the structures as well as get settled in form of debris inside the building affecting furnishing and inventories. Sediments may contain organic matter, tree trunks, roots, rocks, sand and clay, other chemicals and so on (Gissing & Blong, 2004; Tapsell *et al.*, 2010). Flood plains are natural storage area of sediments carried by river, however in time of overflow the water carries these suspended sediments and affects property and health of people in affected areas (NRE, 2000).The damage rate is often affected by rate of rising water. Sometimes sudden rise of water can even cause causalties and lead to rapid destruction. The rising of water is greatly related to slope of land therefore differs from place to place depending upon the location of the property. In urban areas such flows could be associated with high energy and debris flowing through the streets and avenues introducing lot more damage than normal flow of water would do.

2.5.1.4 Flood risk category

The physical vulnerability is also dependent upon the existing flood risk status of the property. Risk categories indicate the level of exposure properties towards hazard. In the UK the flood risk status has been divided into three risk categories. These risk categories are delineated by Environment Agency into significant, moderate and low flood risk zones. The significant risk category of "areas at risk of flooding" means land area within flood zone 2 and 3 that is., moderate and significant risk zones or land within flood zone 1 with critical drainage problems notified to the local authority (Communities and Local Government, 2012). For significant risk category the chances of flooding in a given year is greater than 1.3% (1 in 75) , in case of moderate flood risk the chances are 1.3% or less but greater than 0.5% (1 in 200) and the low flood risk areas have chances of flooding upto 0.5% (less than 1 in 200) (Environment Agency, 2012)

2.5.1.5 Flood defences

Physical vulnerability of properties can be affected by level of protection measures the property is associated with. Protection of flood defences whether it is community flood defences or at property level, both equally affect the total physical vulnerability of properties (Sayers & Meadowcroft, 2005; Joseph *et al.*, 2011). One crucial factor for estimation of losses as a result of flooding is the availability of flood defences in the surronding.

When properties are well protected either by community installed flood defences or property level protection, it is expected that to a certain probability of flooding the potential damage could be managed. With increased building up in flood plains, and the predicted growth of natural hazards like flooding, the number of people and properties at risk of flooding are increasing constantly. Research showed that in different scenarios of predicted future risk of flooding there is chance of increase in number of vulnerable people in floodplain to more than double by 2080 (Hall *et al.*, 2003). The government has declared to spend £2.3 Billion to prevent flooding and coastal erosion till 2015 to protect households and businesses within the flood risk regions alike. Ninety three new flood defence schemes were agreed to start construction from 2013 (Defra, 2013). However, this cannot be stressed enough that the condition of flood risk will further deteriorate as a consequence to the reduced investment policy of government in flood defences for the coming years indicated as “not kept pace” with the rising risk of more frequent extreme weather events (Duggan, 2013; Edie Newsroom, 2013).

This has been emphasized that flood defence installation cannot eradicate risk of flooding entirely, however they can reduce the level of vulnerability to certain extent and reduce economic loss in future (Evans *et al.*, 2004). Reducing vulnerability by implimenting mitigation measures also depend on the perception of affected population towards risk. While it is accepted in literature that all people are vulnerable in hazard areas , the impact of social behaviour to hazard exposure may fall disproportionately to the least prepared and most vulnerable ones (Tapsell *et al.*, 2010). Therefore, understanding social vulnerability is recognised as an integral to understanding risk.The next section discusses the vulnerability in the context of social behaviour of relevant stakeholders.

2.5.2 Social vulnerability factors

Social vulnerability is defined as the characteristics of person or group and their situation that influences the capacity to anticipate, cope, resist and recover from the impact of a natural hazard (Wisner *et al.*, 2003).The social dimension of vulnerability looks into the human agency explicit by drivers of vulnerability imposing pressure on individuals which constrain their responses and ability to cope with disasters (Cutter *et al.*, 2009). This reflects the perception of flood risk and the level of accepted risk among the property stakeholders that is., owners and occupiers (Rose *et al.*, 2012). Social vulnerability describes how and why some communities are more vulnerable than others in spite of being affected by same level of hazards. The socio-economic status of stakeholders influences their ability to absorb losses from hazards (Peacock, Morrow & Gladwin, 2000; Masozera, Bailey & Kerchner, 2007). The components of social vulnerability involve nature of relationships of the physical and societal environment where the system inhabits (Cutter *et al.*, 2009). In case of vulnerability of commercial properties perception of stakeholder's at risk plays an important role in shaping social vulnerability.

Research shows that social vulnerability of the involved stakeholders towards flooding is expected to increase. This can be related with higher to certain public behaviour and will remain an important aspect of flood vulnerability analysis (Hall *et al.*, 2003). Social vulnerability induced behavioural aspects indirectly reflect its impact on both physical and economic aspects for enhancing and effecting resilience (Cutter *et al.*, 2009). Socio-psychological factors like perception of flood risk, experience of flooding, denial of existing risk, knowledge gained from past experiences and expected level of support in times of disruption are some of the most commonly used variables to identify and analyse social vulnerability.

This is also important to recognise that the core of social vulnerability lies in the interaction of people with their surrounding environment putting more emphasis on people. Therefore social vulnerability might not affect the commercial property damage directly at the time of flooding. However, the action of the relavant stakeholders and their perception towards risk is responsible for determining the level of social vulnerability indirectly therefore making social vulnerability very important for the research

Kuhliche studied the relevance of different social vulnerability indicators in the context of European countries in the residential sector (Kuhlicke *et al.*, 2011a). They aimed to find a set of common indicators that can be used for understanding social vulnerability. However, it was observed that there was no common set of criteria for that could explain vulnerability in the social context in a cross country scale. It is very area specific and highly dependent of local conditions, such as spatial, socio-economic, demographic, cultural and institutional factors (Kuhlicke *et al.*, 2011b). However, there are certain aspects of quantification of social vulnerability that are common to all. These social aspects are often expressed through cognitive factors such as perception of people about certain type of risk (Cutter, 1996; Tapsell *et al.*, 2010). Disasters like flooding can impose stress among people and therefore resilience is highly desirable and it involves both physical and social structures to combine to get safer built environment. In the UK it is hypothesised that the desirability of people in the flood plain to take up mitigation and resilience measures are low. This indicates some barriers that affect their attitudes to underestimate risk of flooding (Krasovskaia, 2005; Correia *et al.*, 1998; Lamond & Proverbs, 2009).

2.5.2.1 Risk perception

Peoples' behaviour generally follows a number of complex processes before getting used to the fact that they are actually under threat. In most cases flood events are considered to be specific and isolated and in-spite of warnings population at risk often deny the threat. Literature also suggested that sometimes to increase awareness of risk that cannot be reduced engenders sense of panic and helplessness leading to risk denial (Jha *et al.*, 2012).This is often noticed by researchers that cognitive factors like beliefs and perceptions about issues like flooding cause reluctance in understanding the reality (Bleda & Shackley, 2008). Emotional constraints often lead to cognitive adjustment and prevent risk of flooding to be perceived. This could be due to the infrequent nature of flooding the initial reaction is disbelief and even after receiving repeated warning people still try to seek further information to confirm the actual threat before taking any action (Drabek, 1999).

Some business sectors in the UK especially the real estate are clearly in denial of the current risk of extreme weather events (Matt, 2007) even though they

are likely to be affected in the near future. Research termed such act of denial or "amnesia" to be "organised irresponsibility" (Wisner *et al.*, 2003; Pryce, Chen & Galster, 2011). Environment Agency in the UK also confirms that some communities at risk choose to be in "state of denial" and points towards complexities of behavioural change (Defra & Environment Agency, 2005). The fear of loss of property value as may also contribute to culture of denial of existing risk in the property sector.

Generation of awareness is the result of perception of risk situation (King, 2000). Realisation of risk of flooding to be perceived as sufficient enough to render action is one of the main barriers among stakeholders in commercial property sector. Factors that frame the perception of business property holders are mainly based on their previous experiences, current knowledge of the existing risk, bound by the spatial and temporal effects and their adaptation to the existing situation (O'Connor *et al.*, 2005; Flynn, 2007; Ho *et al.*, 2008).

Sometimes perception regarding adaptation strategies to reduce risk can be misleading too. For instance, the importance of sandbag use for resisting flood is still essentially perceived by flood plain population as the most effective resilient method (Thurston *et al.*, 2008). Perception of flooding is also related with time. With passing time after an event, people tend to forget the importance of the issue and remain vulnerable to any future event (Waterstone, 1978; Lamond & Proverbs, 2006). Some population migrate out of the higher risk zone leading way to fresh people coming in the flood plain without proper knowledge of the risk (Cutter *et al.*, 2008). The optimum time for taking up risk reduction measure is immedeately after the event however such cases are rare since that is the time when people are more stressed with immedeate recovery action.

2.5.2.2 Awareness

A noticeable observation from literature is the lack of awareness within the commercial property sector stakeholders (Wedawatta, Ingirige & Proverbs, 2011). Awareness varies markedly among population at risk of flooding (Hewitt, 1995). Certain level of desirability is required to be informed. Information regarding general flood situation are easily available online and maps indicating risk of flooding are

freely available in Environment Agency website. However the general lack of interest among flood plain dwellers and population at risk is a major hindrance to it. It is not only lack of interest that hinders awareness but some crucial information is hard to obtain. There is certain information such as depth, velocity and damage from previous flooding which are not easily accessible. The unpredictability and uncertainty involved in risk of flooding and technical jargon in reports published ushers population to avoid such routes of obtaining information (Ibrekk *et al.*, 2005; Waterstone, 1978).

The Regulation advisory committee recommended that there is a need for enhancing overall awareness and change in public behaviour towards risk of flooding as less awareness is clearly less motivation for people to take action against flood risk (Regulation Advisory Council, 2009). A number of awareness programmes are sponsored by government to enhance public level of awareness in the UK, but it is noticed that 'specific actionable information is often lacking' (Lamond & Proverbs, 2009). Effective information regarding risk of flooding and mitigation sources are often unclear and ambiguous and not from credible sources. Therefore population at risk are confused and install products which are ineffective for them, thus loosing belief in the adaptation measures (Waterstone, 1978).

2.5.2.3 Experience

Flood experience is a big driver in decision making for adaptation of resilience measures and reducing vulnerability. It has been noticed that population with higher experience of flooding are more active in taking up mitigation measures (Messner, 2007). Those who do not have any flood experience or have only experienced flood once have a tendency to ignore the risk. Although this is an 'overly simplistic' explanation it has been observed that properties those survived previous flood events generally take more initiative to act against the repercussions of floods than those who did not have any experience of flooding (Rose *et al.*, 2012; Wisner *et al.*, 2003). The stress of being flooded and lingering effect on business have the power to affect the population for a long time. This situation makes it more important to focus on the understanding of why such common practice in relation to flood hold in commercial property sector in the UK. Research highlighted the importance of incorporating lessons learned from past experience of flooding in

future assessment of resilience and preparedness. However, reluctance to adapt risk reduction measures even after experiencing flood can be due to the perception that indication of flood risk can bring down the existing value of the property and make it less desirable to in the real estate market.

2.5.2.4 Expected level of support

Lack of awareness, insufficient knowledge and training of how to overcome an unexpected disruption often force people at risk to depend more upon existing emergency services (Bowker, 2007). A high percentage of people ignore the risk being over-reliant on the existing defence measures. The commercial properties especially the sme's hardly have any backup contingency plan either due to lack of funding or they do not take flood as a major risk for their business (Bhattacharya *et al.*, 2011). Studies have shown that in most cases flood affected population would expect government to take responsibility of their suffering and install defences and other relevant measures to protect them (Werritty *et al.*, 2007; Krasovskaia, 2005).Often knowledge about the problem does not help as actions are often deterred by erroneous belief in effectiveness of community defence and lack of information about alternative risk reduction strategies (Thurston *et al.*, 2008).

There is also the aspect of over-reliance on flood insurance although, more than half of UK businesses are either uninsured or underinsured (AXA, 2009). Policies for flood insurance cover for commercial properties is generally offered with an additional premium with the existing insurance (ABI, 2009). Evidence suggests that cost of premium and excesses has increased much higher from the pre-flood conditions (up to 46% for premiums and 1750% for excesses) which reduces considerable the claimable damage for commercial property holders especially SME's (Ingirige, Proverbs & Wedawatta, 2012).

The Association of British Insurers decided upon some guiding principles based on which the "Statement of Principles" with the government was agreed (ABI, 2008). This arrangement was organised after a long discussion and debate following the 2007 UK flood claim with the insurers and the government confirmed on the basis that significant risk protection measures will be taken particularly to those

properties which are at high risk zone and as part of a series of agreements this arrangement continued until June 2013.

The ABI and the government agreed on a new memorandum of understanding after June 2013 that a non-profit scheme will be established from summer 2015 which will ensure affordable and available insurance for those in significant risk of flooding with the help of partnership funding (ABI, 2013). However this principle has totally neglected business properties and therefore it makes it difficult for the businesses to tackle the issue of risk reduction through insuring their properties. Property valuation and investment market is highly dependent on insurance status of assets reflecting reduced risk (RICS, 2012a; Pottinger & Tanton, 2012). Recently, researchers have been warning investors and commercial property lenders not to depend too much on insurance rather than reviewing the existing due diligence to check whether the risk of flooding in the property to be invested are duly covered (Oliver & Hayne, 2012). Therefore systems are vulnerable both internally and externally. As a result there is constant interaction between the two. The next section on Environmental vulnerability will explain the interaction in detail.

2.5.3 Environmental vulnerability factors

Environmental vulnerability of a system can be expressed as the ability of the system to cope with the changing nature of exposure within and outside the system. The system has two components: intrinsic which is related to the inherent properties of the system and extrinsic components which are external to the system (Villa & McLEOD, 2002). The vulnerability depends on the existing condition of the elements at risk and the potential of the external hazard and exposure that might affect the system.

Research in the field of flood vulnerability and resilience encouraged adaptation of resilience measures as key focus of current approaches to flood management (Lamond & Proverbs, 2009; Lamond *et al.*, 2009, 2011; Proverbs, Brebbia & Penning-Rowsell, 2008). The environmental vulnerability plays an important role by acting as a link between the internal coping capacity of the stakeholders of commercial property sector and their interaction with external factors

like global and local market conditions. This aspect of vulnerability implements an integrated agenda of research by incorporating the social and environmental vulnerability within the commercial property system. This in turn, indirectly affect the scale of resilience and consequently on the outcome of vulnerability of the property (Turner *et al.*, 2003a; McLaughlin & Dietz, 2008; Patwardhan *et al.*, 2009; Kuhlicke *et al.*, 2011b). For commercial properties, the interaction between internal characteristics of properties and stakeholders and external exposure factors are equally important to the outcome of total vulnerability. The potential of the commercial property system to regulate its response to external stressors is determined by the characteristics of the system (Williams & Kaputska, 2000). Internal influencing factors like over-reliance on technological support and their chances of failure, such as dam failure or belief of being protected because of an existing flood defence in the vicinity can raise the exposure and thereby level of environmental vulnerability (Martin, 1996).

2.5.3.1 Infrastructure quality

According to a World Bank publication infrastructure quality can contribute towards benefits in economic growth and sustainable future only when it provides services that respond to effective demand efficiently (World Bank, 1994). Attributed to the frequency and damage caused by flooding the UK government is spending about £800 million every year in managing flood risk through coastal and flood defences (Environment Agency, 2009b). In addition to Environment Agency's flood warning, mapping and advisory processes, the total level of vulnerability of properties depend on infrastructural quality and maintenance to a large extent.

Association of British Insurers reported that about 43% of flood defences are in 'fair, poor or very poor' conditions (Staff, 2012). Research show that more properties have been constructed on flood plains because of overdependence on flood defences (Hall *et al.*, 2003). The city of London is one such very important example where the value of property is highest in the UK (Kenney *et al.*, 2006). Over-dependence on technology and limited knowledge of "avoided risk" may enhance vulnerability (Chang & Falit-Baiamonte, 2002). Furthermore, the quality of infrastructure and appropriate design for the property can also affect level of vulnerability by enhancing or reducing the resilience level. Therefore to encourage

stakeholders to be self-reliant, adaptation of resilience measures on a property level should be pursued to reduce vulnerability.

2.5.3.2 Preparedness

Preparedness against flood risk requires readiness and awareness to limit losses (Kron, 2002). Literature has also suggested that people's memory subside with time (time sensitivity) and when there is a substantial gap between events people no longer remember and lack desire to take actions or try to gather insights from their past experiences. This can result in making them more vulnerable to forthcoming stresses and decline in preparedness against future risk (Proverbs & Lamond, 2008). The relationship is not straight forward, as there are several cognitive factors that may have significant impact on the motivation for preparedness (Rose *et al.*, 2012). Preparedness measures can be adopted in pre-flood or post flood situations. The measures can be individual at property level or community wise such as installation of flood defences. Community collaboration for preparing for post flood recovery is effective to reduce disruption. Individual skills and knolwdege regarding risk reduction strategies are important at this stage.

Flood protection measures can be divided into two major subdivisions: the "soft" measures for instance insuring properties, financial security etc. and the "hard" or tangible measures like sustainable buildings and infrastructures. Among the hard measures two effective ways approved by Defra, (2007) are resilient measures which reduces the effect of flood water on the structures and resistant measures which does not allow flood water to enter the property. The combinations of hard and soft measures are more useful for any preparedness purpose. According to a report published by Defra (Thurston, 2008), temporary resistance measures like flood guards, air brick covers, flood shutters might help in reducing the damage to the properties by 50% if properly installed and if with a little more investment permanent solutions for instance flood proof doors and windows are installed then it may prevent damage from 65% to 84%. However, they are not as cost effective in the short run as the temporary measures.

Thirty three percent of the flooded property holders in the UK have some knowledge about sandbags as a resistant method while they are ignorant about other resilient measures. This indicates the need for public awareness for available resilient

and resistant measures.Preparedness within the business organisation comes in the form of organised business continuity plans or emergency recovery plan for smooth business operation. Failure to have a proper action plan for preparing against flooding can lead to higher damage (Bhattacharya & Lamond, 2011). Having adequate business and content insurance can ease the way to recovery in case of an event and reduce the level of environmental vulnerability. For vulnerability analysis there can be a number of interrelated variables which affect the scale of potential damage of the elements at risk. Limited number of variables are listed here to show how these factors can have effect on vulnerability of businesses. The factors can either contribute towards vulnerability in a positive or negative manner and together they determine contribution towards the total flood vulnerability.

2.6 CHAPTER SUMMARY

The chapter provided a critical review of the literature on "vulnerability of commercial property towards flood risk". The basic terminologies have been defined and two main aspects of vulnerability- direct and indirect vulnerability of commercial business properties have been reviewed. The chapter considered the associated factors for different aspects of physical, social and environmental vulnerability within the context of commercial property as a system. The response and recovery measures available to business properties and their attitudinal aspects to adopt mitigation measures also clarifies the level of existing vulnerability in the commercial property system. This chapter has achieved its aim of attaining knowledge on aspects of vulnerability of commercial properties towards flooding. The following chapter will continue the discussion with the second theme of review that is 'property value and its vulnerability with response to commercial properties'. This concept is inherent within economic vulnerability and therefore will help into delineating the relationship between flood vulnerability of commercial properties and their value.

CHAPTER 3. PROPERTY VALUE AND FLOOD VULNERABILITY

3.1 INTRODUCTION

The chapter aims to focus on review of literature surrounding the theme of property value. The objective is to critically review the literature to develop a better understanding of the existing patterns, themes and issues associated with commercial property value in the context of environmental hazards, particularly flooding. Chapter 2 reviewed the concept of flood vulnerability from several disciplines with focus on physical, social and environmental dimensions of vulnerability. The fourth dimension of economic vulnerability is introdued here which has direct relationship with property value thus introducing the concept of vulnerability of value.

The chapter commences with a discussion of understanding property value followed by theoretical aspects of economic vulnerability and its relation to the research domain of property value. The chapter is then summarized followed by identifying the different themes derived from integration of both research domains of flood vulnerability and vulnerability of value from literature.

3.2 UNDERSTANDING COMMERCIAL PROPERTY VALUE

The term commercial property covers a wide spectrum of properties. Consequently factors that affect the value of those properties are numerous and diverse. Commercial properties are income producing premises used for business purposes such as office buildings, leisure centres, retail, industrial, warehouse and manufacturing (Blackledge, 2009). The common aspect for all commercial properties is, they are used in expectation of profit which in long term determines the market value of the property (Shapiro, Davies & Mackmin, 2009).The concept of value is defined as “the price most likely to be concluded by buyers and sellers of a good or service available for purchase” (International Valuation Standards Committee (IVSC), 2007). The price is paid for the utility of the object of interest and the satisfaction gained from its expected provision. In real estate research the criteria that any good or service must possess to have value are utility, scarcity, demand and transferability (Blackledge, 2009). The utility of the property lies in its usefulness for

respective purpose. The scarcity and demand factors in the market are potentially dependent upon the interest and attractiveness of the buyers and sellers' interaction in the market. The transferability of ownership keeps value of property dynamic in the market by purchase and sales which is determined by demand and supply of the property in the market. Factors that affect these indicators of value in negative manner make the value vulnerable in the market.

3.2.1 Property value and participants in market

The commercial property market is influenced by wide range of factors and participants affecting the property cycle of demand and supply. The characteristic of property cycle is influenced by existing economic conditions in the market at any point of time. The main participants within the commercial property market are the buyers, sellers, selling agents, lending institution, local government and media (Egan & McGuirk, 2000).

The buyer or purchaser (and renters) of the property represent the demand side of the market (Pagourtzi *et al.*, 2003; Blackledge, 2009). Normally the buyers or renters are supposed to ascertain any negative feature (such as high flood risk) of the property and negotiate the price or rent based on that.

The seller or the vendor represents the supply side of the market. The sellers are often reluctant to recognise any detrimental feature or characteristics (such as vulnerability to flood risk) that may affect the property value. The responsibility of the selling agent is to market the property on behalf of sellers or vendors (RICS, 2011, 1992). They seek to obtain the best price for the property without misleading the purchaser or renters of any known aspect of the property when questioned.

Lending institutions help the property buyers by lending money. The importance of lending institutions in the market is their possibility of accessing flood risk information and having influence on long term impacts on property value. However, it is difficult to assess such reflections from the market and implement it to mortgage lending policies (Pottinger & Tanton, 2011).

Local government authorities are responsible for planning and building controls. The sale of property should abide by the rules of planning authorities.

Properties in flood risk areas need to get permission from Environment Agency for extension of premises.

Finally, the media plays an important role in building perception within the property market. Advertisements of properties available in the market are done through different media. News, property magazines and other relevant media sources can also play an important role in developing knowledge of existing risks. For example there was vast media coverage for the 2007 flood and the floods events after that, and understandably they tend to focus on the residential property (Pottinger & Tanton, 2011). Media can raise issues of awareness related to flood risk in certain locations, make people aware of new defences build or more local notification of auctions and so on. Media can also cause concern for property owners that the value of their property might get affected due to over exposure of information regarding flood risk.

The positivist economists involve theories of 'revealed preference' or what is and was or will be? (Lipsey, Langley & Mahoney, 1985).In contrast, the concept of value for this research deals in the idea of value to be 'what it should be that is, the concept reflects in people's judgements, knowledge, philosophical and cultural positions to identify the value of an object. The cause and effect relationships between different market aspects concerning commercial properties and their internal characteristics are dynamic. Therefore it is not straight forward to define the term easily.

Consequently, the expression of value is often reduced to a monetised form by the concept of willingness to pay (Shapiro, Davies & Mackmin, 2009). The concept depends on how much more or less society or people are willing to pay towards a particular good. The extent of willingness can be determined by the perceived losses which could be harmful to the property and business. This can result in value reduction through measures provided by market (Hall *et al.*, 2003). As disasters are viewed as chance events (probabilistic), it is often observed that people choose the degree of risk they are willing to bear based on their perception of the problem and knowledge of adjustment options (Chang & Falit-Baiamonte, 2002; Slovic, Kunreuther & White, 1974).

Complexity in determination of property value in terms of its need can prove to neglect the risk of flooding as it does not come as a priority for the property holders. As a result of the difficulty of evaluation of the effect of an external factor like flood risk on value of property, economists have argued that measurement of value of a desirable item by measuring the individual's readiness to pay to keep the item at a certain state of performance (Turner, Pearce & Bateman, 1994). This willingness to pay can also be measured by analysing the reduced utility in property performance (Lake *et al.*, 1998). Willingness to pay can be broken down into the actual price paid plus the consumer surplus that is, the amount the consumer would be willing to pay over and above the actual price paid (Lamond & Bateman, 2011). Property value especially market value is dynamic in characteristics, with a number of external and internal factors playing their part in the dynamism.

3.2.2 Dynamism of property value

The Royal Institution of Chartered Surveyors provide standards to demonstrate that value of a property can be affected by physical, social, economic and political assumptions about the status and condition of the asset, especially for commercial properties (RICS, 2011). The potential of a property's value to be economically vulnerable to changes of external criteria such as flood risk can be directly associated with the how the property is economically vulnerable to changing stresses within its system. The general outcome from the effect of external criteria is on the utility of the property. Utility of property is disturbed by external forces in affecting income generation. This can make the property vulnerable to recover economically. Report on climate change, argued that if the changes in the property value can be understood by actions of humans, and weighs them in financial terms it would be possible to direct future policy and thereby help to prevent negative environmental change (Stern, 2006). In terms of market value, the market recognised utility and satisfaction provided by the real estate is more important than that of its pure physical status (Wyatt, 2009).

The concept of market value' is generally the focus of discipline of valuation research. Market value is defined as the 'money obtainable from a person or persons willing and able to purchase an article when it is offered for sale by a willing seller' (Millington, 2002). However, this is rather simplified and there exist a whole range

of subjective factors that affect market value of any given commodity. Research showed that the attributes that has the potential to affect market value of commercial property are namely, the physical characteristics of the property, locational factors, importance of use, type of ownership, performance of the property in the long run and services and facilities availed to the occupiers (Fuerst *et al.*, 2010). Time also plays an important role in changing value of property (Wyatt, 1995). The factors can be classified into internal and external dimensions that affect the commercial property system. Taxonomy of the four significant factors: time, property characteristics, location and terms of rent or sale that influence property values is noted by Royal Institution of Chartered Surveyors (RICS, 1992) [adapted from (Wyatt, 1996)] is presented in Figure 3.1.

The internal factors include physical characteristics of the property. They also include legal factors effecting lease terms of property. Built form is the physical characteristic of property includes the type of building, geometry, construction, level of insulation and immediate surroundings (Wright, 2008). Other involved physical characteristics are structure and size of the property which are determined by the building regulations, allocated space and contemporary designs.

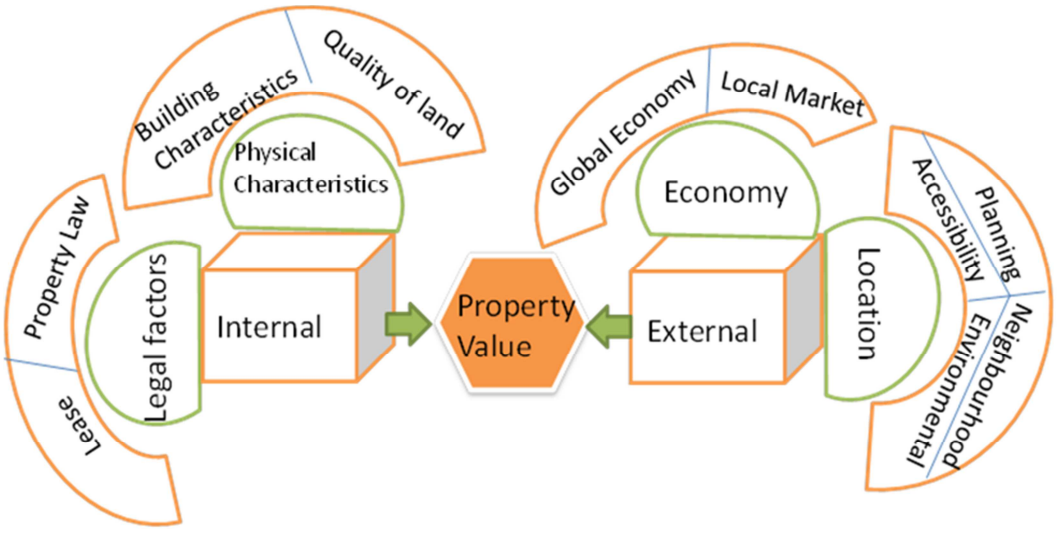


Figure 3.1 Taxonomy of factors affecting property value [Adapted from (Wyatt, 1996)]

Previous research has shown that larger properties tend to be valued at a lower rate mainly because they tend to be used as warehouses or are generally located out of town (Fuerst & McAllister, 2011). Number of floors has higher effect on value depending on the best purpose to which it can be put to use (Britton, Davies and Johnson,1989). Furthermore, age of construction can also have an effect on the various built form factors and structure of the building and enhance chances of higher damage in case of a flood event. These physical characteristics are also inherent features of the physical vulnerability of the property towards direct flood damage.

The market value of commercial property depends not only on the probable useful life of the property but also on its possibility of redevelopment and refurbishment. The aspect of regeneration and redevelopment can be influenced by regulations. It is important to take into account the total expenditure required to maintain the property at certain level (Wyatt, 2009; Shapiro, Davies & Mackmin, 2009; Fuerst & McAllister, 2011). The physical state of the building, and its legal status assessed by its lease terms are important indicators of value fluctuations (Connellan James, 1998; Fuerst & McAllister, 2011). A number of contracts can be seen on lettings which can be distinguished based on the financial capacity of the business holder. They vary between large multiple concerns with higher security of income to smaller businesses with limited resources (Blackledge, 2009).

One of the important external factor influencing value of commercial properties is its location (Tim & Richard, 1996; Shapiro, Davies & Mackmin, 2009; Wiggins, 1979; Wyatt, 1996). This can be subjective to different type of commercial properties based on factors like accessibility, experience and local knowledge (Debrezion, Pels & Rietveld, 2007; Blackledge, 2009). Although location of property varies on type and requirements of business, still it remains a major factor for achieving expected turnover as large variation of value can be observed in a comparative range of short distance (Adair *et al.*, 1996).

Single, multiple and ancillary use of property, is another factor in determination of property value. The factor involves classification on the basis of use such as retail, industrial, warehouses and offices. The proportion of assigned floor space used for each activity is important factor for determining pricing for properties

(Fuerst *et al.*, 2010). Use of space for offices might be emphasized along with location and transport connections as properties or land with most accessible locations are higher in demand and value (Wyatt, 1996). The considerations taken while a person or institution agrees to pay higher for a property depends on the recognition that it has trading potentials as well, that is, the property has potential to generate income in the future (Shapiro, Davies & Mackmin, 2009).These aspects contribute to locational factor of property value by incorporating environmental, access, and neighbourhood elements. Fluctuations in market conditions can have sudden effect on value; however the uncertainty in this case is quite large since there are no standards to assess such uncertainty (Wyatt, 2009).

The value of property is a reflection of performance of property, for example higher growth and better return in prime location of properties have a tendency to generate higher value (Fuerst *et al.*, 2010; Eichholtz, Kok & Quigley, 2009). Moreover, property value is judged by the services and facilities it provides to its occupiers. The level and quality of provision of facilities help in gaining attractiveness for the property and command higher value (Fuerst *et al.*, 2010). Furthermore, responses of relevant stakeholders towards taking up adaptation measures to protect properties from being vulnerable to different market criteria can affect level of vulnerability (Berkhout, Hertin & Arnell, 2004; Dahlhamer & Tierney, 1996; Crichton, 2006).

The economic performance of a property can be determined by changes in rateable value, market value, total return from the property and changing operating costs. There is always uncertainty in measuring the actual effect of the factors involved in the dynamics of property valuation (Stanley *et al.*, 1998; IAAO, 2001). Recent research in property performance emphasized that properties with superior performance deliver more potential to the stakeholders and they benefit from improved productivity and provide competitive advantage to the property (Fuerst & McAllister, 2009). This in turn will attract bids from potential occupiers for the property (Fuerst & McAllister, 2011). An overall effect of economic situation in the market and global economy always has an effect on the fluctuation of value. However, economic situation of the market affects all properties, the assumption is that if a property is already vulnerable to other aspects a bad economic climate can have a multiplier effect on its vulnerability and make it more vulnerable in the

market than others. These factors can be assumed constant. From the above discussion it was observed that many factors add to the dynamism of property value. It is important to understand the process through which a damaging factor (such as flooding) can impact on the dynamism of property value.

3.2.3 Understanding detrimental condition and its effect on value

Detrimental condition caused by natural or anthropogenic factors affecting property value can be associated with six basic processes (Bell, 1998).They are:

- original value of the property when no effect occurred
- cost or losses associated with occurrence of the detrimental condition,
- assessment cost, the repair and recovery cost;
- cost associated with time lost during recovery (for use of property) meaning the ongoing cost
- the market resistance for residual risk cost

The pattern of change in value will involve some or all of the six basic processes. These elements are well represented by the detrimental condition model proposed by Bell (1996) in Figure 3.2. After the occurrence of any detrimental condition, the first type of cost that has impact on the property value is the impact assessment cost. This cost is associated with all monitoring and situation analysis works. The actual repair cost continues through the ongoing cost. A vast spectrum of direct and indirect costs could be included in this stage. The ongoing cost can be higher if extra monitoring is required for condition assessment of the property after recovery. There are certain restrictions in normal use of the property in every stage thus affecting the income generation. Finally, when the property is ready to be used again the final resistance might come from the market in form of resistance to purchase as a result of history of detrimental condition.

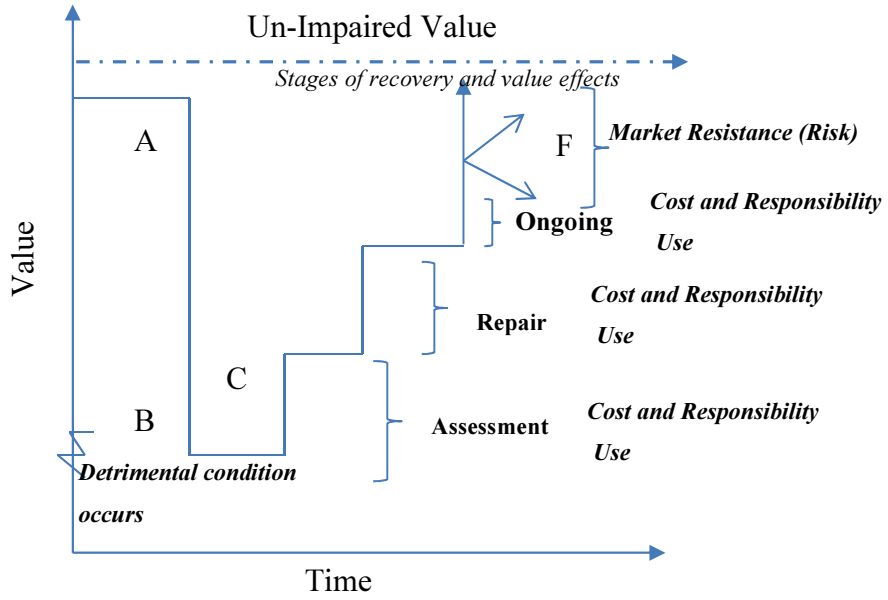


Figure 3.2 The Detrimental Condition model [adapted from (Bell, 1996)]

When market realises that there is a problem with the property, value can be significantly affected by various factors such as disclosure requirement by seller or agent and problems in getting lenders, and appraisers uncertainty regarding the property (Mundy, 1992; Roddewig, 1996). This can have a negative impact on the marketability of value of the property (Mundy, 1990). The main criteria indicated in every stage of the detrimental condition model are cost of damage and disruption, responsibility of recovery and impact on use of property. The most critical factor here is the hindrance in use of property to generate income.

The impact of natural conditions such as flooding involves a number of safety issues for the property occupants and the existing assets. It is possible to recover value if all stages of detrimental conditions are taken care of. However, the risk still remains of the residual conditions which might involve uncertainty in the system. The stigma of the history of detrimental condition (flooding in this case) can still have an impact on the future value of the property (Roddewig, 1996; Mundy, 1992). The best way to identify impact is to look at the vulnerability of the property value before the occurrence of any event, during the repair stage and finally after the recovery stage to understand the difference between unaffected and affected property value (de Vries, 2011). Understanding the condition of the property through this

cycle of events requires to venture into the inherent condition of the commercial properties, in the form of their strengths and weaknesses to perform in times of emergency. For commercial properties, this means understanding their inherent business vulnerability which in time can have an impact on the desirability and marketability of property.

From the above discussion it can be observed that several overlapping physical, social, environmental and economic factors affect value of property either directly and indirectly. The economic vulnerability acts directly upon the performance of commercial property system. The first three factors have been discussed in Chapter 2. The following section will elaborate on the fourth type of vulnerability, that is, economic vulnerability of commercial properties. The aim is to identify the main factors affecting businesses and making them vulnerable towards failing property performance.

3.3 ECONOMIC VULNERABILITY AND VALUE

The value of commercial properties is a function of the total profit acquired from the property where business is settled as a result of the interaction between buyers and sellers due to their mutual interest (Bell, 1998; Shapiro, Davies & Mackmin, 2009). When value of property is exposed to internal or external changes, there is a chance that the property system will be economically vulnerable as explained in previous section. The factors discussed in the previous section such as impact of detrimental condition on property utility, changing perception of people and its impact on the marketability of property indicates a direct relationship with the concept of economic vulnerability along with physical, social and environmental vulnerability of commercial property system.

Economic vulnerability is defined as the exposure of a system to exogenous factors of economy, market, policy and the system's inherent capacity to withstand and recover from sudden shocks (Briguglio *et al.*, 2009). Focussing the discussion directly to flood risk situation, economic vulnerability is predicted to increase in areas where flood risk is significant (Hall *et al.*, 2003).Roughly twenty fold increase in annual flood damage scenario is perceived by 2080 which is attributable to combination of much increased economic vulnerability. The factors associated with

increased vulnerability will be flood plain occupancy, increased asset values of contents, increased vulnerability of infrastructure and so on. Such changes can also be seen in changing ratio of flood risk to per capita GDP when compared to the growth rate over next century (Hall *et al.*, 2005).

Economic vulnerability of commercial property sector, affecting the vulnerability of business performance, is a strong predictor of the attractiveness of the property itself (Rose & Lim, 2002; Powell & Hardin, 2009). Change in attractiveness of property due to reduced utility can lead to reduction in property value (Bhattacharya *et al.*, 2011). The probability of occurrence of interruptions in business falls within the scope of economic vulnerability. Such vulnerability helps in understanding how characteristics of business properties can affect property value. This also involves other neighbourhood factors (disruption of infrastructure services such as utilities and transportation) can have impact on value of property (Chang & Falit-Baiamonte, 2002).

Vulnerability differs between sectors based on the level of exposure, susceptibility and resilience of available assets (Zhang, Lindell & Prater, 2009). As a result, economic vulnerability is related to the dynamics of business continuity and recovery. The pattern of change on production, sales and profit of an organization in a pre and post disaster situation can illustrate such dynamics within the commercial property system (Alesch, Holly & Nagy, 1998, 2001b; Kroll *et al.*, 1990). The following section will illustrate the dynamics of economic vulnerability and its several interacting dimensions with commercial property as antecedent system state and the external detrimental factor of risk of flooding. The aim is to indicate how the effects on its different conditions can have an impact on businesses and subsequently on value.

3.3.1 Factors affecting economic vulnerability

Research demonstrates that business continuity and recovery of commercial properties can be affected by factors such as direct physical damage, indirect disruption in transport and utility services, and operational difficulties in demand and supply (Tierney, 2007; Tierney & Dahlamer, 1996). It has been identified that the factors that mainly trigger economic vulnerability are: amount of available assets,

market diversification, level of dependence on other businesses; size, location, purpose and ownership of business; reconstruction level, labour and organizational flexibility, and mobility factors (Wedawatta, Ingirige & Amaratunga, 2010a; Bhattacharya & Lamond, 2011). Some of these factors are static while others dynamic in their characteristics within the system. The following discussion will demonstrate each factor in detail.

3.3.1.1 Exposed Assets (Sector)

Commercial properties are exposed to a wide array of risks characterised by probability of flood events. Research indicated that assets are key factor in determining the level of economic vulnerability (Vatsa, 2004; Hall *et al.*, 2005). Assets help the affected population to mobilize resources in face of shocks and recover faster (Moser, 1998). Technically, risk is defined as loss that occurs or exceeded with a given probability (Seifert *et al.*, 2010). Assets can be classified based on the nature of element at risk. When assets are classified based on type of properties it mainly means economic activity undertaken by the commercial property. Therefore exposed assets differ between specific sectors.

The UK standard Industrial classification of economic activities divides commercial practices into nineteen divisions based on their type of activities (Office of National Statistics, 2007). Therefore exposed assets varies with different sectors and the damage and disruption also varies consequently. Exposure can be expressed by physical condition (structural integrity, age) of the building, machineries, inventory, furnishings, produced goods and so on (Adger, 2006). The level of vulnerability varies with the type of asset, for example for fixed and unmovable assets flooding is disastrous unless they are installed in resilient manner. For movable assets vulnerability can be reduced by moving them to safer locations. The value of asset with reference to time depends on the variation in market conditions.

The spatial differentiation is associated with the regional specification of assets, market value, rate of wage and so on. These variations bring deviations in economic vulnerability. Literature suggest that the manufacturing sector has the highest damage potential due to higher damage ratio for equipments, goods and stocks in Germany (Kreibich *et al.*, 2007). The multi coloured handbook published

by Middlesex University showed that the retail sector on an average has the highest weights in terms of damage in the UK.It is followed by office, factory and warehouses (Penning-Rowsell *et al.*, 2010). However as indicated earlier with changing location, function of sector and type of impact there might be variation in vulnerability among other sectors.

3.3.1.2 Size of business

The size of business is often measured by number of employees (staff headcount) and is correlated with the ability of the business enterprise to cope with disruption caused by disasters (Alesch, Holly & Nagy, 2001b; Wedawatta, 2013).Based on the definition provided by European Commission enterprises having less than 10 employees fall under micro organisations, those with less tha 50 employees are small and those having less than 250 employees are defined as medium enterprises (European Commission, 2006). Any other values over 250 fall under large sized enterprises.

The impact of flooding is expected to be more devastating for small and medium sized businesses than larger organisations (Ingirige, Proverbs & Wedawatta, 2012). However some researchers have also observed counter intuitive results (Webb, Tierney & Dahlhamer, 2002). Recent flood events in the UK has established how costly such events can get for small and medium sized sectors (Pitt, 2008; ABI, 2010b). The main reasons why small and marginal profitable enterprises take longer to restore back to their original stage after a disaster corresponds to lack of resources, and low financial capacity to recover faster from the impact. Other factors such as dependency on a smaller market for profitability, lack of resource and knowledge for capacity building add to the problem (Webb, Tierney & Dahlhamer, 2002; Zhang, Lindell & Prater, 2009; Dahlhamer & Tierney, 1996). Businesses with larger market and higher financial capacity are expected to be in a better position to recover from disaster faster as they can disperse the risk factor in multiple locations.

Large enterprises are financially more capable both in times of disaster and normal situations. This enables them to adapt resilient infrastructures for enhanced protection. They are also able to afford hazard insurance with high premium when required, make available separate contingency funds and business continuity

insurance to cope during the disruption period and get back to pre-disaster situation as soon as possible. This is sector specific within the commercial property system; for instance whole sale and retail enterprises are particularly vulnerable to flood loss, sectors like construction and manufacturing might actually gain after the initial physical losses, in a post disaster scenario where their sales expands due to demand for recovery and restatement of affected areas to original condition from other sectors (Bhattacharya *et al.*, 2011).

3.3.1.3 Ownership

Differential ownership of property raises issue of responsibility of capacity building and adaptation of mitigation measures to safeguard the property from future impacts of flooding. Literature shows owned business properties are more capable in undertaking precautionary measures than leasehold properties. Precautionary measure are able to restrain damage by 25%-100%. (Kreibich *et al.*, 2010; ICPR (International Commission for the Protection of the River Rhine), 2002). Better information of the terms of lease contract often provide comprehensive understanding and financial agreement between landlord and tenant. This may also helps in understanding the environmental impact and performance of property (Fuerst *et al.*, 2011). People renting or leasing properties for business are often on internal repairing lease rather than full repair, therefore the responsibility in maintaining the structural integrity of the building lies in the hands of the owners. Unless the owner of the business property is aware of the risk of flooding and afford the precautions undertaken to reduce damage, properties remain vulnerable towards impacts of flooding (Howe, 2011). Ownership is related to state of repair of buildings.

Ownership can also act as a proxy for financial success of business, since owning a property means that there may more opportunity for the business to be successful if it can move premises at will in times of need. Owners occupied businesses can also decide to make structural changes in modifying their buildings for flood resilience (Chang & Falit-Baiamonte, 2002).Rented properties can take longer time to recover because it becomes the liability of the owner to repair as an aftermath of disaster (Tierney & Dahlamer, 1996). Therefore, better information on lease terms or ownership patterns would provide a comprehensive picture of the

financial agreement between landlord and tenant which can detail the the impact of environmental performance on the property .

3.3.1.4 Labour mobility

Labour contributes to business production with their knowledge and skill. In case of disruption prepared businesses more effective in coping with ease of labour replacement are more likely to come through the disruption and recovery phase (Merz *et al.*, 2010). For this purpose a separate labour pool is required and large branches or multi locational firms are more likely to have such provisions than small and medium organisations (Zhang, Lindell & Prater, 2009). Besides extreme cases of death, injury or sickness from flooding which hinder business operation, lack of access to reach work place can also affect labour shortage creating temporary operational disruption of business properties. Replacement of labour is not easy as quality can be hampered. For instance in such situations businesses might have to depend on less skilled labours.

Flexibility of labour organisation in terms of flexible working hours and working from different location other than the one affected by flooding is essential for smooth running of business and faster recovery. However, disruption in access to workplace sometimes cost employees to take longer and costlier routes to follow which causes delay and extra stress (Kroll *et al.*, 1990). This affects the scale of total impact on business operation after the actual event has passed. Flexibility in labour organisation, such as working from different location can reduce such problems (Zhang, Lindell & Prater, 2009). This however differs according to the type of business as not all businesses can perform their ususal business operations from remote locations.

Labour mobility and business operations from different locations in time of disruption is very important for getting back to business as ususal situation faster. Businesses whose operations are limited by mobility can suffer economically more than others (Wedawatta, Ingirige & Amaratunga, 2010b). Not only physical mobility but businesses with more financial mobility with regard to holding more capital resources (inventories, cash, securities etc.) are less prone to economic vulnerability (Zhang, Lindell & Prater, 2009). Fixed assets is considered to be a capital resource

but they are highly vulnerable as they have lower mobility and can be affected more by physical disturbance.

3.3.1.5 Market diversification (primary market)

Market diversification influences the customer dimension of business properties (Zhang, Lindell & Prater, 2009). Commercial properties may be serving at local, regional, national or international levels. The vulnerability of businesses with localised primary market can be more than those having a larger market base. This is because, if businesses are constrained within the area of impact and their market is constricted locally then often it becomes difficult for quick recovery from the shock (Chang & Falit-Baiamonte, 2002). It is expected for businesses which are well spread in the market and have larger share in regional or national levels, the cost of damage can be distributed with the profit accumulated from the other market areas (Bhattacharya *et al.*, 2011).

Risk of flooding is considered among 'specific risks' which are unique to each asset and the effect is not equal on all assets. Therefore through diversification of market business properties may be able reduce their economic vulnerability to certain level (RICS, 2011). However, if the market in other locations are also affected by flooding, it is possible that the impact will be larger for those businesses with larger dependence on other markets or businesses in other locations (Zhang, Lindell & Prater, 2009). Over reliance on businesses in other areas of impact can lead to failure of operation in businesses of areas of non-impact. This can indirectly affect businesses in both areas. Supply and demand can reduce which can result in reduced turnover. There are often high dependence between businesses and very few alternatives.

3.3.1.6 Location

Location is considered to be one of the most important characteristics for business in commercial properties (Wyatt, 1996). The most sought after prime location can maximise turnover for certain types of commercial property. Location in the context of vulnerability includes the proximity to the risk source, closeness to inundation area, location in hazard zone delineated by Environment Agency (Messner & Meyer, 2005). These indicators inform the exposure of the property at

risk of being inundated or indirectly affected. Location of properties in particular zones in the flood plain can introduce confusion and complications in getting flood insurance and affect the resilience level of properties and its value (Lamond, Proverbs & Hammond, 2009). Alternatively, the so called safe locations away from rivers can be also affected by other types of flooding such as ground water and surface water flooding. For instance in the UK 3.8 million people are at risk of surface water flooding (Environment Agency, 2009b). Not only the location of the property at risk is the main concern of business property sector, location of suppliers, customers and communication links are equally important for determining level of disruption to the businesses of commercial properties.

The performance of property is widely accepted to be affected by locations and impact of flooding is likely to be greater in some areas than others. Therefore, over time it is expected that 'more secure locations' are likely to be more desirable and less economically vulnerable (Pottinger & Tanton, 2011). Location is often critical for smaller businesses because of the lack of affordable insurance and more concentration of population in flood plains. In order to be more resilient, businesses need to move to safer locations. However factors such as existing customer base in the flood plain area that keeps them from not moving out. In the UK there are about 2 million properties build in high flood risk area out of which 130,000 are business properties (Environment Agency, 2009b). Therefore, existence of flood defences and other forms are defences may prove to be beneficial in reducing vulnerability of some properties.

3.3.1.7 Financial resources and annual business turnover

The value of property can be assessed as soon as it can be put to a profitable application (Temple & Dent, 1998). Generally business turnovers are calculated annually and if there is a disruption in the operation of property it shows at the end of the term of business. The size of businesses are also determined by their annual turnover and number of employees according to European Union Law (Burk, 2006). This classification is however affected by the type and purpose of business as for some business sectors, for example oil companies where the corporation sizes are extremely large the sectors can be classified as small in comparative measures (Ingirige, Jones & Proverbs, 2010). Hence to investigate economic vulnerability,

knowledge and potential effect of flooding on percentage of annual turnover can provide better understanding of economic vulnerability of business.

There is however limitation on how such data can be gathered as getting statistics regarding turnover of businesses are generally commercially sensitive and protected by law (Floodsite, 2007). Many researchers adapted the approach of calculation of total damage of properties by taking annual turnover as one of the prime variable (Penning-Rowsell & Chatterton, 1977; Penning-Rowsell & Parker, 1987; Booysen, Viljoen & Villiers, 1999). Studies also found that businesses already in financial difficulty at the time of disaster may find it difficult to recover and as a result may also relocate to other locations especially if they do not own the property (Tierney, 1994). Therefore is important to incorporate the factor of what was the situation of the business before and after the event in terms of its total annual tunover, number of employees and changes in customer for a longer period of time (Chang & Falit-Baiamonte, 2002). Depending on whether the business was doing well or not before the disaster might have a consequence on its capacity to recover and stabilise after the impact (Webb, Tierney & Dahlhamer, 2002).

Another concern for commercial property holders is financing sources of recovery. There are several options available for instance, business reserve, commercial loans, self-funding,insurance and so on. Due to the lack of recovery funding, there might be delay in re-establishing business. Sometimes buying habits of customers can change during that period causing cash flow freeze. Similarly, those who rush into reopening businesses just after disaster, there might be customer shortage resulting in cash flow squeeze (Alesch, Holly & Nagy, 2001a). In either way the tempation is there to hang on until things get back to normal which can cause frustation and anxiety to mount, and savings to dwindle. Literature suggests that the capacity of control over external forces can often influence the desire of being prepared. For instance people with perception that they have some degree of control over external stresses are more willing to undertake mitigation measure than their counterparts (Powell & Hardin, 2009; Spittal *et al.*, 2008). Many of such perception factors have been discussed in the social vulnerability section in Chapter 2. It is expected that better off businesses with more resources to draw on may have easier recovery than those without sources of funding or are self-funded. However

counter intuitive results have been seen in both hurricane and earthquake affected disasters where better off firms had more to lose in a disater than the financially marginalised counterparts (Webb, Tierney & Dahlhamer, 2002).

Renegotiation of rental or sales value as a result of flooding may have some impact on the market value of property.Incidence of renegotiation in a post disaster scenario identifies the impact of the disaster in the market. As seen in the residential sector that customers often query about flood risk as it is a requirement for insurance terms (RICS, 2004), it is essential to observe if such incidence occur in the case of commercial porperties. As flood insurance threatened by reduced availability and higher premium, can be a concern for the property investors (Pottinger & Tanton, 2012). It is not clear in the market how any renegotiation as a result of risk will be dealt with, it is an active discussion among property investors in the UK which makes it an essential part of this investigation (Marsh, 2011).

3.3.1.8 Level of reconstruction

The expected damage from flooding is mainly based on the level of reconstruction or replacement value of the elements at risk (Messner & Meyer, 2005). Higher capacity of reconstruction in post disaster situation is effective in reducing vulnerability of business properties. This factor is inter-related to other influential factors such as availability of finance for reconstruction, adaptation capacity of the business to recover from shock and overcome disruption, authorities, institutions and insurance companies plans for supportive role in helping businesses to speed up reconstruction and training to carry out reconstruction adequately on time (Ginige, Amaratunga & Haigh, 2010). Strategies are required to enhance level of reconstruction and capacity building among business properties to reduce level of economic vulnerability (Crichton, 2007). Existing and proposed plan for flood defences can also help in reducing vulnerability of a percentage of exposed properties. Although evidences suggest that it is not possible to protect all flood affected properties and such measures can give people false perception of reduced risk. The quality of infrastructure play an essential role in this regard albeit, the importance of defences cannot be ignored (refer to section 2.5.3.1).

Flooding can cause indirect effects by interfering with essential services such as energy, water, communication and transport services. Environment Agency reports, during 2007 flood event in Gloucestershire, major infrastructure were affected and 40,000 people were left without electricity for 24 hours with innumerable others left on the railway tracks without any source of transport. In Tewkesbury, 140000 homes were left without clean drinking water up to 17 days. Loss of essential services can impact on a larger area that the flooding has actually occurred. Supply of essential services during disaster help in faster recovery from disruption. However, in the UK about 7000 electricity infrastructure sites and 900 pumping stations are at risk of flooding. Besides that 10% of the main roads and 21% of railroads are also at risk of flooding (Environment Agency, 2009b).

Effective measures in building plans and back up services is also required to reduce economic vulnerability of properties with reference to essential services. For example, use of porous material for construction, building heating installations, gas lines, electricity lines in levels where water can easily reach may make them more prone to damage (Kenney *et al.*, 2006; Proverbs & Soetanto, 2006). Similarly, hazard mitigation in the form of business continuity plans and recovery plans are essential aspects of vulnerability reduction (Bhattacharya, Lamond & Proverbs, 2011). A detailed explanation of organisational behaviour and different options of preparedness is provided later in the chapter.

3.3.1.9 Purpose and proportion of floor space used

The intended use of property is responsible for affecting its value to a large extent (Temple & Dent, 1998). When utility of property is restricted due to damage caused by flooding, it affects use of property. Flooding often hampers the purpose for which the property is used for throughout the phases of impact and recovery. Such conditions can impact upon the income generated from the property leading to loss in revenue generation (Bell, 1998). Sometimes neighbourhood construction and repair also hampers property's full use by causing obstructions (Tierney & Webb, 2001). Therefore such activities indirectly affect customer access blocking full utilization of the property.

Proportion of affected floor space is an important variable for flood damage potential, especially for commercial properties such as industrial, retail or manufacturing premises. The proportion of total floor space used provides an important indication of their damage potential in case of flooding. Floor space and their value varies enormously throughout the country for different sectors. Office of Deputy Prime Minister releases the data for Commercial and Industrial floor space and Rateable Value by bulk class for each local authority. Damage per square metre has been considered appropriate for commercial property sector as an unit area for estimation of damage in 'absolute damage estimation approaches' (Floodsite, 2007; Gissing & Blong, 2004; Penning-Rowsell *et al.*, 2006). With higher exposure of floor space to risk there is chance of greater damage and disruption. Therefore consideration of proportion floor space as a factor of exposure in determining economic vulnerability is undisputable.

The inherent vulnerability within a commercial property system and the attitude of property owner towards risk also determine how they will mitigate risk in times of need. From the above discussion the most important aspect of vulnerability reduction that surfaced is the level of response and preparedness for recovery from impact of flooding. The following section will detail the organisation's risk dealing strategies to reduce vulnerability followed by situation of business properties in terms of recovery from the effect of sudden disruption of business and the different preparedness options available to commercial properties.

3.4 RISK DEALING STRATEGIES OF ORGANISATIONS

In times of disaster, business continuity is one of the primary motivation of any profit making enterprise. Ensuring continuity comprises of analysis of impact and identifies sources of threat to identify the enterprises' level of exposure. It is necessary to synthesize prevention and protection measures in a pre-disaster scenario and respond and recover faster after an event to ensure continuous business operation.

Previous research in the field of disater adaptation indicated that most businesses in the commercial property sector do not fail just after an event, rather they take some time to recover and then fail as a result of impact of pre and post

disaster vulnerability factors (Powell & Hardin, 2009).It is during the recovery phase where the survival of the businesses becomes difficult. Such situation is the result of losses suffered by business does not always have immedeate effect after an event but it takes time to reflect in the recovery stage. Furthermore, most stakeholders in the business sector are not fully aware of the actual risk and are not well prepared to recover from sudden shocks (Alesch, Holly & Nagy, 2001a).

Business continuity planning, structural hazard mitigation and purchase of insurance are important factors for hazard mitigation. There are certain behavioural and economic factors that affect the actions of business properties to take actions against disasters. This has been noted previously that interest in implementation of flood hazard action plan in business sector is more popular among those who have past flood experience while others do not take it as a major threat (Gissing, 2003; Gissing & Blong, 2004). Other strategies like moving elsewhere during the time of flooding, working from home or in flexible hours, getting advice for flood related insurance schemes and capitalizing on the risk review from their exposure to the risk are also available.

Another option of risk reduction is not to depend entirely upon community flood defences but to install property level flood protection measures (Joseph *et al*., 2011). However, it cost benefit research suggested that property level measures are only profitable to those properties which are subjected to annual risk of 4% or more that is., enterprises under the flood risk zone of 25 years return period (Thurston *et al.*, 2008). Such uncertainties in probabilities often make property owners less interested in obtaining insurance against flooding even if it is available.

Research also showed that the barriers to developing the desire for adoption can affect level of vulnerability among business properties. The root cause behind low flood plain populations'desirability and ability to adapt risk reduction measures are indicated in Table 3.1 (Lamond & Proverbs, 2009). Although desirability factors are primarily concerning residential property sector, but these factors are equally relevant to commercial property sector too.

Table 3.1 Barriers to developing desire and building ability to take up adaptation measures by risk affected population

		Barrier			
		Financial	**Information**	**Emotional**	**Timing**
Desire	Awareness	No	Yes	Yes	No
	Perception	Yes	Yes	Yes	Yes
	Ownership	No	Yes	Yes	Yes
Ability	Knowledge	Yes	Yes	No	Yes
	Resource	Yes	No	No	Yes
	Belief	No	Yes	Yes	Yes

Adapted from (Lamond & Proverbs, 2009)

Flood experience can have a bigger impact on organisational behaviour. It has been observed that in a post 2007 situation property consultants have experinced "a boom in flood due diligence work, increased awareness of environmental risk and sensitivity to impact of transactional value and reputational risk" (Pottinger & Tanton, 2011). Support and cooperation from local authorities may also help to shape adaptation decisions. One study showed that most support from such organisations go to households instead of businesses, the number of buinesses that receive flood warning is lower and also most help that businesses obtain from insurance companies are generally with an expense of high premium (Crichton, 2006). Pre-disaster preparedness is not taken as priority measure among commercial properties. For preparedness actions literature provides the evidence that business occupiers tend to favour those measures that are more easily accessible where they do not have to invest much (Tierney & Webb, 2001). Although there are several options for disaster preparedness, but anticipating and planning for quicker recovery through preparedness is yet to get adequate importance in business sector.

3.5 OPTIONS FOR PREPAREDNESS, RESPONSE AND RECOVERY FOR VULNERABILITY REDUCTION

The committee on disaster research in social sciences has rightly suggested that enterprises or businesses who are engaged in preparedness and mitigation activities will be less vulnerable to natural disasters (Committee on Disaster Research and Social Sciences, 2006). Pitt's report after the 2007 flood event (Pitt, 2008) recommended the neccessity of adaptation of property level resistance and

resilience at all types of properties in the UK. Flood protection measures can be divided into two subdivisions: the "soft" measures which includes insuring properties, financial security, having disaster recovery plan and so on; the "hard" or tangible measures involve adapting preventive measures for sustainable buildings and infrastructures. Two effective and approved ways among hard measures are resilient measures which reduces the effect of flood water on the structures and resistant measures which does not allow flood water to enter the property (Bowker, 2007).

Literature emphasized that combinations of hard and soft measures are more useful for any preparedness purpose (Proverbs & Soetanto, 2004). According to a report published by Defra, temporary resistance measures like flood guards, air brick covers, flood shutters might help in reducing the damage to the properties by 50% if properly installed. A little more investment towards permanent solutions such as flood proof doors and windows, may prevent damage from 65% to 84% (Thurston *et al.*, 2008). Although such installations may incur higher financial burden to the property owner compared to temporary measures. The same source points out that 33% of the flooded property holders in the UK have some knowledge about sandbags as a resistant method, while others are not aware of other alternative resilient measures. This indicates the need for public awareness for resilient measures.

There are some options for preparedness and adaptation measures that can help commercial properties in reducing vulnerability. There are chain of actions that can bring enterprises to adjust to the hazards in a quick and less damaging manner, if they are well prepared for the mitigation activities. For any preparedness programme understanding the basic concepts of hazard assessment, estimation of exposure to risk, development of chain of warning system, bringing awareness among stakeholders, planning evacuation strategy, contingency planning and recovery planning are necessary (Strunz *et al.*, 2011). This is also pertinent to identify the critical assets that are exposed to risk and have higher vulnerability as already explained in previous sections of this chapter. Information about location, material and type of building, distribution of apparatus, personnel and function of infrastructures are of highest importance (Committee on Disaster Research and

Social Sciences, 1999). Decreasing operational risks by improving protection to important documents, backing up by secure information management system can be very helpful for enterprises of all sizes. Insurance is one of the major areas of mitigation and remain prepared against impacts of flooding. However, about 90% of the small and medium enterprises (SME) in UK do not have insurance cover for their protection (AXA, 2008).However, business response to preparedness canbe affected by indirect factors like rising value of insurance premiums in high risk zones, unavailability of insurance, terms of insurance policies and lack of knowledge of commercial property insurance.

Flood vulnerability can be reduced by keeping the elements at risk well informed through media. Factors like early response to warnings; consideration of warning dissemination time and evacuation time from the building; removal of vehicles, other apparatus and cash; keeping the path of water clear to manage flow velocity; turning off electricity, water supply and gas supply to save unwanted accidents; saving property by shutting vents, using basic measures like sandbags, flood shutters, flood guards, airbrick covers water barriers and sharing information with the stakeholders are important for faster response and recovery (Gissing, 2003; Thurston *et al.*, 2008). Recovery processes can be more effective if scrutinized and undertaken along with local partnership with flood defence authority, district councils and political involvement to reduce level of vulnerability (Savage, 2007). This is because complete recovery and continuation of business is only possible when the whole affected area recovers by means of opening of roads and crucial services, clearing of debris and so on. Total recovery activities need cooperation from local government as well as individual property holders. Quick recovery can help in reducing subsequent impact on vulnerability of value of flood affected properties.

3.6 THE CONCEPT OF VULNERABILITY OF VALUE

The different dimensions of vulnerability noted in Chapter 2 and this Chapter indicates the complexity of relationship between characteristics of the commercial properties and the value of different components exposed to risk. The connection of commercial property value with vulnerability components can firstly, be directed towards physical damage caused by immediate effect of flooding. The initial impact

is followed by the time and actions taken to recover from the damage to get back to business as usual situation (Tierney, 2007). Impact on the income generation is possible from the commercial property if the time for recovery is longer. Recovery from direct impact of flooding requires consideration of issues like hosing out water, cleaning of debris, thorough checking of utilities, assessment of damage and removing damaged contents for restoration of business.

Direct physical damage call for faster emergency relief services. Indirect disruptions demand financial assistance, employees' return to job, suppliers and consumer adjustment to the market, and essential service management.It is essential to recover and restore vital records which can help in bringing back business continuity. Location advantage for larger enterprises in resilient areas helps in risk reduction and faster recovery from floods while smaller enterprises might suffer more as a result of their financial constraints (Tierney, 1997). Lost documents during flood events, for example insurance papers, tax return documents, tracing orders etc. might act as a hindrance to the recovery process. Some of the other handicaps of flooding which makes properties significantly vulnerable to early recovery, for instance production inefficiency, reduction in supply, quality accreditations and licensing problems (Aba-Bulgu & Islam, 2007). Reluctance of finance companies to pay for the affected property and high premiums set by insurance companies for flood prone properties can prove to be fatal for the recovery process. Such actions can have catastrophic impacts on many businesses; one report suggests that around 43% of the properties closed down after a disaster and about 29% of those closed down within two years (Wenk, 2004).

Secondly, the vulnerability is affected indirectly depending on the property's capacity to adapt to the changing circumstances over time (by maintaining short and long term income generation) (Wedawatta, Ingirige & Proverbs, 2011; Kenney *et al.*, 2006).The dimensions of physical vulnerability in understanding impacts on value is greatly associated to the direct physical damage of asset values and reduced utility of the property's function. Therefore disruption of property utility becomes the first point of interaction between commercial property value reduction and disaster vulnerability.

Besides physical damage economic vulnerability can have significant impact on the value of property in the long run. One of the factors in determining property value is present total income generated from the business in the property and the expected income from the property in future (Jackson, 2001; Zhang, Lindell & Prater, 2009; Pottinger & Tanton, 2012). It is possible that properties within significant and medium risk of flooding are likely to experience more loss of income as a result of frequent flooding. However, there are several factors that can affect the income generation from business and value of property. For instance, as mentioned earlier prime location is considered to be an important aspect of income generation for a business. In certain cases, it can be difficult for the business owner to bring a balance between their risk taking and profit making strategies. Again, risk of flooding can be controlled by taking up adequate resilience measures, for example insurance; having said that, the factors such as availability and cost of insurance can be a hindrance in their way.

When the factors affecting economic vulnerability affects businesses income generation, then with time it can affect the desirability of the property in the market. Therefore the link between reduced utility of the property and its desirability in the market could be observed. In case of social vulnerability, influence on adaptation strategy of stakeholders and changing their perception towards risk can either aggravate the existing vulnerable condition or reduce it by introducing resilience in the system. The perception among buyers and renters can change the desirability of property as a result of stigma caused by risk status of the property or history of flooding in the area. The resilience factor is further affected with differential level of environmental vulnerability by contributing to the property owner's level of preparedness. A sustainable flood resistant property will be more desirable in the market; therefore, its marketability in the real estate sector is expected to increase. As a result, it is also possible that with expectation of reduction of risk, increased income generation and demand of high risk properties, investment towards making the property resilience can increase. Such steps can possibly increase the desirability of properties in the market. Although it is hard to say that lowering flood risk will definitely enhance property value as it depends to a large extent to the market perception of the buyer and the seller at a particular point of time. However more loss of income due to larger disruption from flooding will result in higher income

loss and longer recovery time and may be able to change the perception in future. Besides resilience building flexibility in lease term can impact upon demand for a property, which can make the value of properties high even in areas of significant risk. Combination of all such factors can also property occupiers to ignore the flood risk exposure as a secondary issue and concentrate on gaining the most from the existing situation. Therefore interaction of demand and supply in the market is a combination of several vulnerability factors which determine the willingness of the participants within the market to pay towards a particular property.

Scientists often argue that vulnerability should not be confined within the definition of "degree of loss" only rather; it should be an integration of several indicators in the form of "characteristics of human, social and physical environment". Such holistic approach identified through variables help in understanding the factors that influence the change in the original state of a system (Kappes, Papathoma-Köhle & Keiler, 2012; Birkmann, 2006). The concept of vulnerability is applied in the context of built environment and its complex relationships with characteristics and circumstances in the form of physical, social, economic, and environmental factors. The integration demand understanding of the larger picture of the commercial property system exploring its exposure, sensitivity and resilience (Jones, 2012). Thus all four components of vulnerability are important to be involved in expressing total vulnerability towards value of the commercial property (Tierney & Webb, 2001; Gissing & Blong, 2004; Bell, 1998).

The two facets of knowledge gaps in vulnerability and value research have been brought together in a coherent piece. The review of literature on both themes of flood vulnerability and vulnerability of value identified factors that have been persistently reported in somewhat scattered and disparate manner in several related literature. This helped in identifying themes for a better understanding of the research aim (see abridged table of literature used for operationalisation in Appendix 1).The identified themes to integrate different aspects of flood vulnerability and property value will further help in development of the conceptual model which will be discussed in detail the following chapter.The motivation behind selection of the concept of vulnerability assessment lies in its appropriateness in identifying the forward looking variables without the need for extensive market transaction data for

commercial properties (Zhang, Lindell & Prater, 2009). In the absence of adequate market data, the incorporation of information needs to obtained from commercial property occupiers as participants which can be critical in the later stages of analysis.

To summarize, from the discussions above and in Chapter 2 a new concept evolved to the vulnerability research: the vulnerability of value. The interplay of different factors of physical, social, economic and environmental vulnerability and their subsequent outcome in the form of disruption of property utility, desirability and marketability helped in understanding the concept of vulnerability of value better. Working definition of the term vulnerability of value can be introduced as the interplay between the potential exposure of the total value of a business property to a given magnitude of flood risk with its internal and external sensitivity and the capacity to overcome and recover from the disruption to restore original condition in the market.

3.7 THEMES AND SUBTHEMES IDENTIFIED FOR VULNERABILITY OF BUSINESS AND VALUE TOWARDS FLOODING

The review of literature helped in identifying subthemes from the two themes of flood vulnerability and property value. Seven sub-themes were derived based on the review in Chapter 2 and 3. The first point of interaction between a commercial property and disaster happens in the form of experience of flooding. This experience can be direct or indirect. A number of criteria related to this sub-theme were identified, such as type of flooding, number of times flooded and how far the property owners were aware of the flood risk. Once a disaster occurs, the next stage is to look for the impact. This is the second sub-theme which includes cost of damage and recovery, time of recovery. Since recovery surfaced as an important aspect of understanding vulnerability of business properties, the level of preparedness came up as the next major sub-theme. This sub-theme identified criteria surrounding type of existing preparedness before and after the occurrence of the event.

The characteristics of commercial properties influence the level of both flood vulnerability and value of property; therefore criteria of commercial property type, time in business, location, market diversification, ownership and mobility of services

were incorporated in the next subtheme. The financial condition of the business and the sources of funding available for recovery plays an important role in understanding vulnerability of commercial properties, therefore the financial condition of businesses were identified as a sub-theme. The renegotiation of property price as a result of flooding can show a direct indication of vulnerability of property value in the market after recovery take place. Therefore, the factor of renegotiation of properties is kept as a sub-theme for understanding value fluctuation in the market. Finally, market perception which includes an interaction between several overlapping criteria from different vulnerability criteria is distributed among property usability, desirability and marketability to indicate the vulnerability of value of commercial property. Table 3.2 details the different sub-themes and the criteria associated with them with corresponding type of vulnerability.

Table 3.2 Themes and sub-themes identified using literature review

Sub-Themes	Criteria	Type of vulnerability
Experience of flooding	Number of times flooded	Flood characteristics , Physical Vulnerability
	Type of flooding	Flood characteristics , physical vulnerability
	Awareness of flood risk	Behavioural aspects of risk awareness; social vulnerability
Impact of flooding	Direct damage	Exposed assets, physical vulnerability, economic vulnerability
	Indirect damage	Business characteristics, physical, social and economic vulnerability
	Cost incurred for recovery	Economic vulnerability
	Time required for recovery	Physical, economic,
	Business interruption cost and time	Potential business disruption Economic vulnerability
	Effect on annual business turnover	Economic vulnerability, business characteristics
Preparedness against flooding	Type of adopted risk reduction measures	Level of preparedness, Environmental vulnerability
	Time of adopted measure	Level of preparedness, Environmental vulnerability

	Existence of community defences	Response to effective demand, Environmental vulnerability
	Effect of community defences on flood risk	Environmental vulnerability
	Effect of community defences on property value	Economic vulnerability
Characteristics of business properties	Location, Size, Type of business, Time in business, diversification in market, Ownership, services and mobility	Economic Vulnerability
Financial conditions	Type of financial sources adopted for recovery	Economic vulnerability
	Rate of recovery in terms of annual turnover, change in number of employees and customers	Economic vulnerability
Renegotiation of contracts	Change in property value as a result of flooding and extent of change	Economic vulnerability, ownership and awareness about risk
Market perception	Property usability, desirability and marketability	Interaction between different types of vulnerability with special reference to social vulnerability cognitive factors

3.8 CHAPTER SUMMARY

This chapter introduced the second literature review theme of "property value" with response to different factors included in the dynamics of the commercial property sector. The discussion followed by description of the different aspects of economic vulnerability and their interaction in the context of flood risk. The theme surrounded the concept of vulnerability of commercial property and their businesses. Several dynamic and static processes are present within the affected system determining the level of vulnerability. The concepts of economic vulnerability and vulnerability of value are presented and their interrelationships are discussed with reference to flood risk. Different risk reduction strategies and organisational behaviour towards adopting measures to reduce vulnerability by reducing future damage are discussed.

The prerequisite for assessing vulnerability that surfaced from the review is the need to define the purpose of measurement conceptually first and then determining the selection criteria for measurement strategy. The following chapter will introduce the design of conceptual model based on insights gained from the literature review. There is a general lack of benchmarks in vulnerability literature for the discipline of value; therefore measurement of vulnerability below a basic acceptable threshold is difficult. As a result it is not possible to directly estimate the vulnerability due to its predictive nature; therefore conceptual model will act as a proxy to the understanding indirect measurement of vulnerability. Further to that a research plan illustrating the methodological aspects of generation of conceptual model, its operationalization and a measurement strategy for the validation of the conceptual output in subsequent chapters will be discussed.

CHAPTER 4. DEVELOPMENT OF CONCEPTUAL MODEL FOR VULNERABILITY OF PROPERTY VALUE

4.1 INTRODUCTION

On the basis of the extensive literature review presented in Chapters 2 and 3 there are grounds for assuming flooding might have some impact on the value of commercial properties. The components of vulnerability and value are identified in the literature review and it is now evident that a number of direct and indirect relationships exist between the two themes and their numerous interacting components. This chapter presents and explains the development of the conceptual model of vulnerability of property value. This was undertaken by clear and extensive theoretical understanding in aggregating the two dimensions of vulnerability and value research by conceptually bringing them together in one platform. The design and development of the conceptual model helped in attaining objective 3 of the research. This chapter presents the conceptual model developed based on the theoretical patterns observed from literature review. The development of conceptual model follows a strategy of nine designed stages which is discussed in the following sections.

4.2 DESIGNING THE CONCEPTUAL MODEL

Different schools of thoughts have distinguished systematization of vulnerability by means of conceptual frameworks. The differences were mainly due to the mirror through which they view vulnerability. The framework for disaster risk community view vulnerability as a separate entity from exposure and coping capacity (Davidson, 1997; Bollin *et al.*, 2003).The school of political economy in a more classical sense encompasses vulnerability systematization as dynamic pressures and unsafe conditions to be the root causes of vulnerability (Wisner *et al.*, 2003). The sustainable development community relate vulnerability in their BBC conceptual framework (based on the works of Birkmann, Bogardi and Cardona) as discourse of sustainable development (Bogardi & Birkmann, 2004; Cardona, 1999). The Double Structure school associate vulnerability in the form of exposure to shock

and stress and the ability to cope with them (Bohle, 2001; Camarasa Belmonte, López-García & Soriano-García, 2010). The global environmental change school of thought proposes vulnerability as lack of resilience among socio-ecological fragilities which encompasses exposure, sensitivity and response capacity (Turner *et al.*, 2003a). The holistic approach integrates the views from global environmental change and the school of double structure together to view vulnerability as the concept of exposure, susceptibility and lack of resilience put together. As a result of such complexities in defining vulnerability within a particular framework there exist divergent methods and complications. However, diversity and lack of convergence is the strength that provides vitality in vulnerability research (Adger, 2006).

The research keeps its views with double structure school of vulnerability which indicates the external and internal factors associated with the concept and the global environmental change approach of vulnerability which views it with broader definition of exposure, sensitivity and response capacity. Chapter 2 of the thesis provided an extensive and critical overview of literature on the theories, principles and concepts of vulnerability in the context of commercial properties. Chapter 3 focussed on the body of literature associated with the vulnerability of commercial property value in the context of environmental hazards particularly flooding. The development of the conceptual model involves a synthesis and integration of the two distinct fields of literature. The integration of the literature on vulnerability and valuation including their criteria and sub-criteria are brought together conceptually to reflect the relationships and interactions that exist. The significance of this model lies in its ability to incorporate different themes into a common ground. The proposed framework incorporates both space and time dimensions. Figure 4.1 shows the methodology adopted and the steps involved in the design and development of the conceptual model.

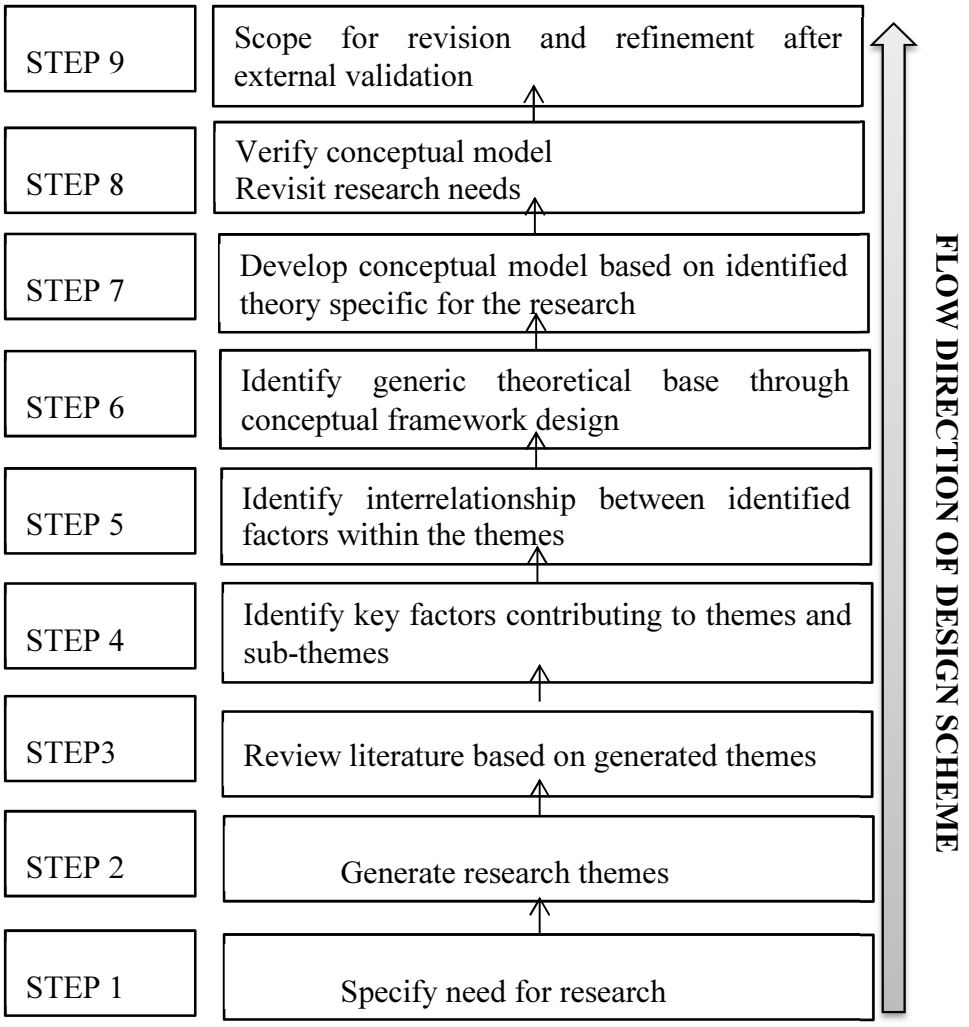


Figure 4.1 Methodology adopted for developing the conceptual model

The first step was to define the research parameters so that the themes and subthemes of the research could be generated based on the research needs. These needs were developed from the research aim and objectives discussed in Chapter 1. Key factors affecting the contribution of the main themes and their sub-themes were identified through an extensive review of the literature. This stage was crucial for the recognition of gaps in the literature and in establishing the scope and boundaries of the research. These stages represented the second, third and fourth steps in the methodology. The fifth step represented the identification of the interrelationships between the different themes. These interrelationships are shown by two conceptual mental maps (Figure 4.2 and Figure 4.3). The first mental map represents the interrelationship between different factors affecting vulnerability of commercial properties towards flood hazard. The second mental map indicates the

interrelationship between variables of property performance and value in the context of exposure to hazard. The sixth step is to identify generic theoretical framework on which the conceptual model will base its ideas on. A generic theoretical framework is designed based on systems theory indicating the dynamic flow path of vulnerable (refer to Figure 4.4) systems and the changing system states through interacting variables. Finally based on the theoretical background from the generic theoretical framework and insights from conceptual maps the conceptual model specific for this research is developed. This is shown by the seventh step in the diagram (Figure 4.5).

Step eight and nine were undertaken after the development of conceptual model through internal and external validation. The first four steps have already been discussed in Chapters 1, 2 and 3.The following sections will continue with step five and continue up to step nine. The next two sections illustrate on the interrelationship between the identified factors from both themes: vulnerability of commercial properties towards flood hazard and vulnerable commercial properties and property value.

4.2.1 Development of conceptual maps

Four dimensions of vulnerability (physical, social, environmental and economic) have been discussed extensively in Chapters 2 and 3. These dimensions reflect the triggers that affect vulnerability of exposed assets. The four dimensions of vulnerability and the interrelationships between them are represented by the conceptual mental maps are illustrated in Figure 4.2 and Figure 4.3.

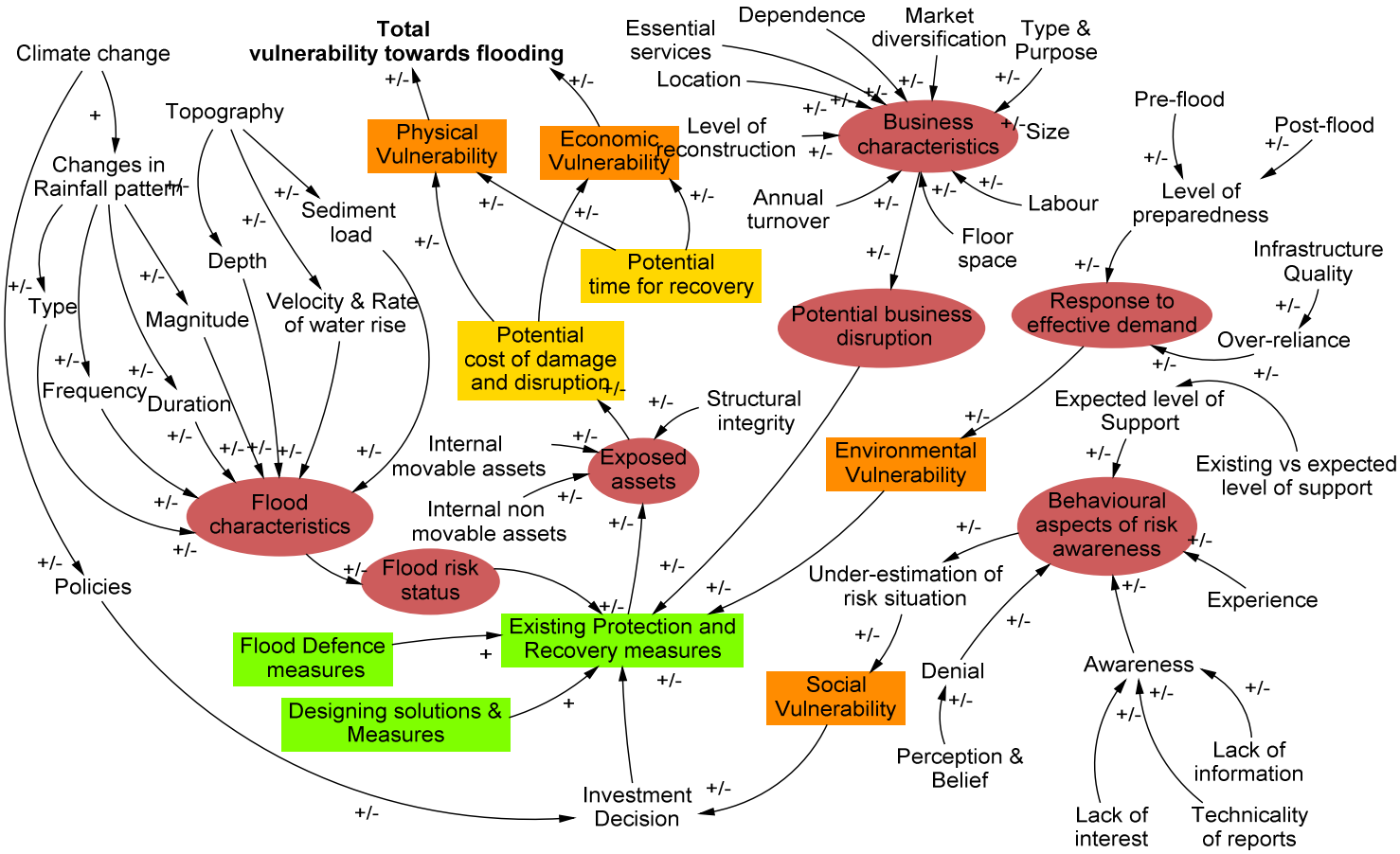


Figure 4.2 Conceptual mental map indicating relationship between variables of four dimensions of vulnerability of commercial properties towards flooding

The dimensions of vulnerability are indicated by orange colour rectangles and factors affecting those dimensions are indicated in brown ovals. Factors which have direct positive effect on the total vulnerability of exposed assets such as existing protection and recovery measures are shown in green and total impacts on potential cost of damage and time for recovery are indicated in yellow boxes. The key dimensions of the map are described in the following sections.

4.2.1.1 Physical vulnerability

The factors associated with physical vulnerability of commercial properties are essentially related to exposed assets in their existing flood risk status and their level of preparedness. Physical vulnerability is associated directly with potential damage and disruption as a result of direct contact of the exposed asset with flood water. The exposure of properties situated in particular locations with differential flood risk depends upon the presence of existing protection and recovery measures. The flood risk status is an outcome of the existing risk of flooding in an area and delineated based on historical flooding and past experiences by testing and retesting of models by the Environment Agency in the UK. These represent external sources of exposure.

Internal sources are the physical and structural vulnerability of buildings arising as a result of construction design and materials (Lindell & Prater, 2003). The main factors are the type of construction material, structural condition of the building, maintenance of the building and the way space is used within the building (Keiler *et al.*, 2006; Proverbs & Lamond, 2008; Kappes, Papathoma-Köhle & Keiler, 2012). The existence of internal movable and non-movable objects such as machineries, furnishing is also part of the exposed assets contributing towards physical vulnerability.

The changing climate can influence the amount of rainfall (frequency, duration and magnitude). This changing nature can result in a greater magnitude and frequency of flooding and therefore affect extent of flood risk. The characteristic of flooding has a direct connection with the physical vulnerability of property. Factors such as speed of onset, intensity, scope, duration of impact and probability of

occurrence are important for understanding the level of exposure to hazard (Papathoma-Köhle *et al.*, 2010). Characteristics including depth, velocity will determine how frequently flood water enters the property and the subsequent damage. Locational aspects of the property such as topography and proximity to flood source can further affect water velocity, rate of water rise and sediment load carried with the water causing higher direct damage to the property (Holub Fuchs, S., 2008; Meusburger & Alewell, 2008). Depending upon the seriousness of flood event the status may change occasionally, however, it is likely that areas with higher risk of flooding are expected to have higher potential damage. These areas will potentially need longer time for recovery unless the existing recovery and protection measures can handle the abrupt change in the system. The interaction between these factors is illustrated in the conceptual mental map in Figure 4.2.

4.2.1.2 Economic vulnerability

Physical damage of property is directly linked with the economic impacts of flood damage. These two factors are inter-connected through potential cost of damage of exposed assets which integrates physical vulnerability and economic vulnerability together. The inherent economic vulnerability of commercial property is determined by the business characteristics that affect the generation of income from the property. These characteristics include type and purpose of property, size and annual turnover, market diversification, labour mobility, dependence on other businesses, building and floor-space used and capacity of reconstruction and services provided. When any one of these factors is disrupted by floods it can result in longer recovery time and loss of business performance. This in turn results in reduced utility of the property. If the existing protection measures are not in place then it might lead to severe disruption of business thus making business performance economically vulnerable.

The potential cost of damage, disruption and time of recovery of business properties can be reduced by investing on protection and recovery measures. Many commercial sectors dependent on large physical assets like construction, manufacturing, and infrastructure can be climate sensitive and indirectly affected by lack of insurability which has potentials to affect property value. However, it is a

challenge for property owners and tenants to judge and make decisions to adapt to changes. This is because of the uncertain nature of characteristics and impacts of flooding on the commercial properties (Stern, 2006). The positive and negative influences are dependent on the type of risk reduction actions taken by property occupiers (before or after flood) and the changing characteristics of flooding. The impacts are indicated with both positive and negative signs due to the changing nature of influence depending upon changing situations.

4.2.1.3 Environmental vulnerability

Level of preparedness against flood risk is also linked to environmental vulnerability. Such a link is created by the outcome of response to effective demand for protection measure. This is again dependent on the uncertainties in level of resilience of properties. The quality of infrastructure is important for understanding the level of protection it can provide to the properties. Additionally susceptibility of structure also depends on the state of maintenance of building. Standard of maintenance of buildings can affect the total damage potential of property in future (Uzielli *et al.*, 2008) therefore poorly reinstated building following one flood will be more vulnerable to future damage. Standard of maintenance can also affect the cost of building repair and replacement value during the recovery phase. Historic factors such as knowledge of previous flood and the damage caused by the historical flood is one of the prime criteria that help in identifying effective demand for preparedness. Environmental vulnerability is closely related to physical vulnerability and acts as a pathway to affect total vulnerability.

4.2.1.4 Social vulnerability

The behavioural aspect of risk awareness and mitigation is intertwined with the inherent social vulnerability of commercial properties. It is determined by the awareness, denial, experience, expected level of institutional support of affected population in times of disaster and other relevant behavioural aspects affecting perception of flood plain population (Kuhlicke *et al.*, 2011b). The adoption of property level protective measures by property owners and tenants is directly affected by their social vulnerability and their understanding of risk (Tapsell *et al.*,

2010). Behavioural aspects can not only affect under-estimation of the risk situation but can also impact on decisions towards adopting resilient measures to reduce future flood vulnerability.

The significance of this conceptual mental map lies in identifying the interaction between various factors and selecting the common features that affects all four dimensions of vulnerability. Based on the above narrative two main factors identified as essential for understanding total vulnerability of commercial properties towards flooding are ***potential cost of damage and disruption and the potential time required for recovery***. These two factors are considered to be the main elements for understanding the business vulnerability against differential flood risk situations. This is evident from the above discussion and the conceptual map demonstrates that vulnerability of business is an essential factor for understanding vulnerability of property value. Property value can be affected by a reduction in the performance of the business and the utility of the property for business purposes as a result of flooding. This link between utility of property and the corresponding impact on value is illustrated in the next section.

4.2.2 Interrelationship between the business vulnerability and property value of commercial property

A discussion of the vulnerability of commercial property value towards flooding has already been presented in Chapter 3. Insight gained from the discussion indicated that two types of impacts can have effect on property value: firstly, a physical event like flooding which can cause direct and indirect damage to affect property value; and secondly, a change in the understanding of risk perception among property holders. The first mental map (Figure 4.2) helped in understanding the vulnerability of commercial property and their business processes against direct and indirect effects of flooding. The corresponding effects on different dimensions of vulnerability created the ground work to comprehend how differential business vulnerability might affect value of commercial properties through a similar process. In this section the narrative will surround the concept of how property performance can be commercially hampered and utility can be reduced as a result of exposure of the asset towards flooding. Since value is closely related to the performance and

utility of property it is essential to identify the interrelationship between the levels of vulnerability of the business in the property and its corresponding value. Figure 4.3 indicates the interconnections between the various interacting factors influencing the performance and utility of property. Utility and exposure of assets are shown by orange colour and influencing factors indicated in red. Property value is illustrated in yellow.

Two factors, namely the physical characteristics and the business characteristics of property can have a direct influence on the performance and utility of a property. Physical characteristics of property determine the level of exposure of assets inside and outside the property. Business characteristics determine the capacity of property to perform in times of disaster. As explained in the previous section the physical or structural characteristics of property determine the level of physical vulnerability. Physical vulnerability of property can be also influenced by social and environmental vulnerability as seen in the conceptual map (Figure 4.3). The performance and / or utility of property are an outcome of interaction between several components of vulnerability. When the utility of property is exposed to enhanced vulnerability it might not be able to cope with the stress from damage and disruption. As a result there will be longer delays in recovery from impacts. The value of businesses is largely determined by the level of utility of a business and its capacity to recover. Physically damaged property requires higher operating costs for repair and maintenance which might affect the value of the property directly. Physical characteristics of commercial properties have been extensively discussed in the section associated with physical vulnerability.

Except for the structural and business characteristics another factor that has influence on level of vulnerability is financial resources available for recovery. This comes from the financial capacity of the business holder. This factor determines how soon and well the reconstruction will be to preserve the utility of the property.

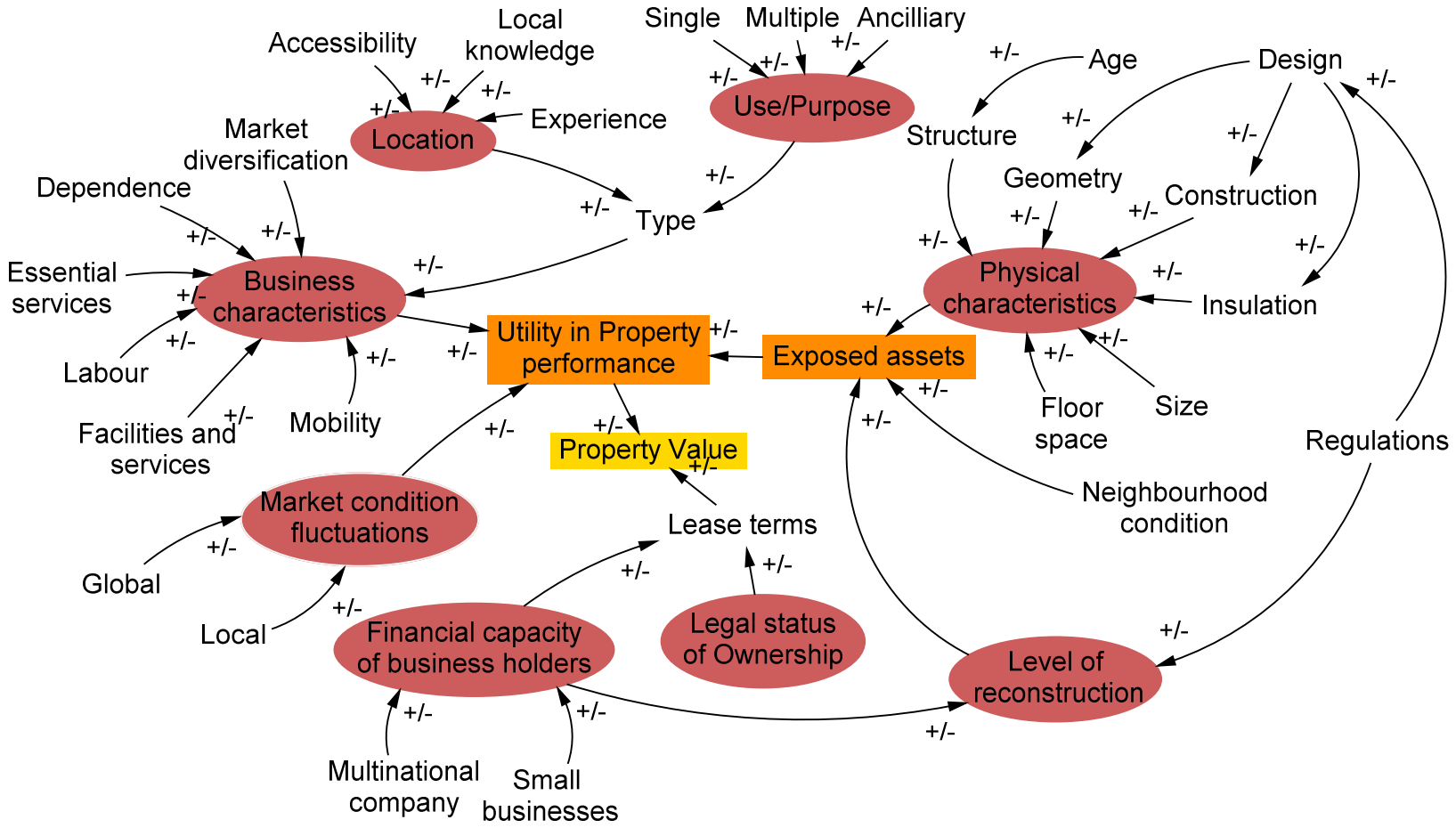


Figure 4.3 Conceptual mental map indicating relationship between variables of vulnerability of property performance and value

The assets and resources in commercial organizations are interconnected into a value chain which includes purchasing operations, sales, marketing, services, finance, research and development, supervision as well as general administration. These factors can be affected by differential business characteristics directly or indirectly.

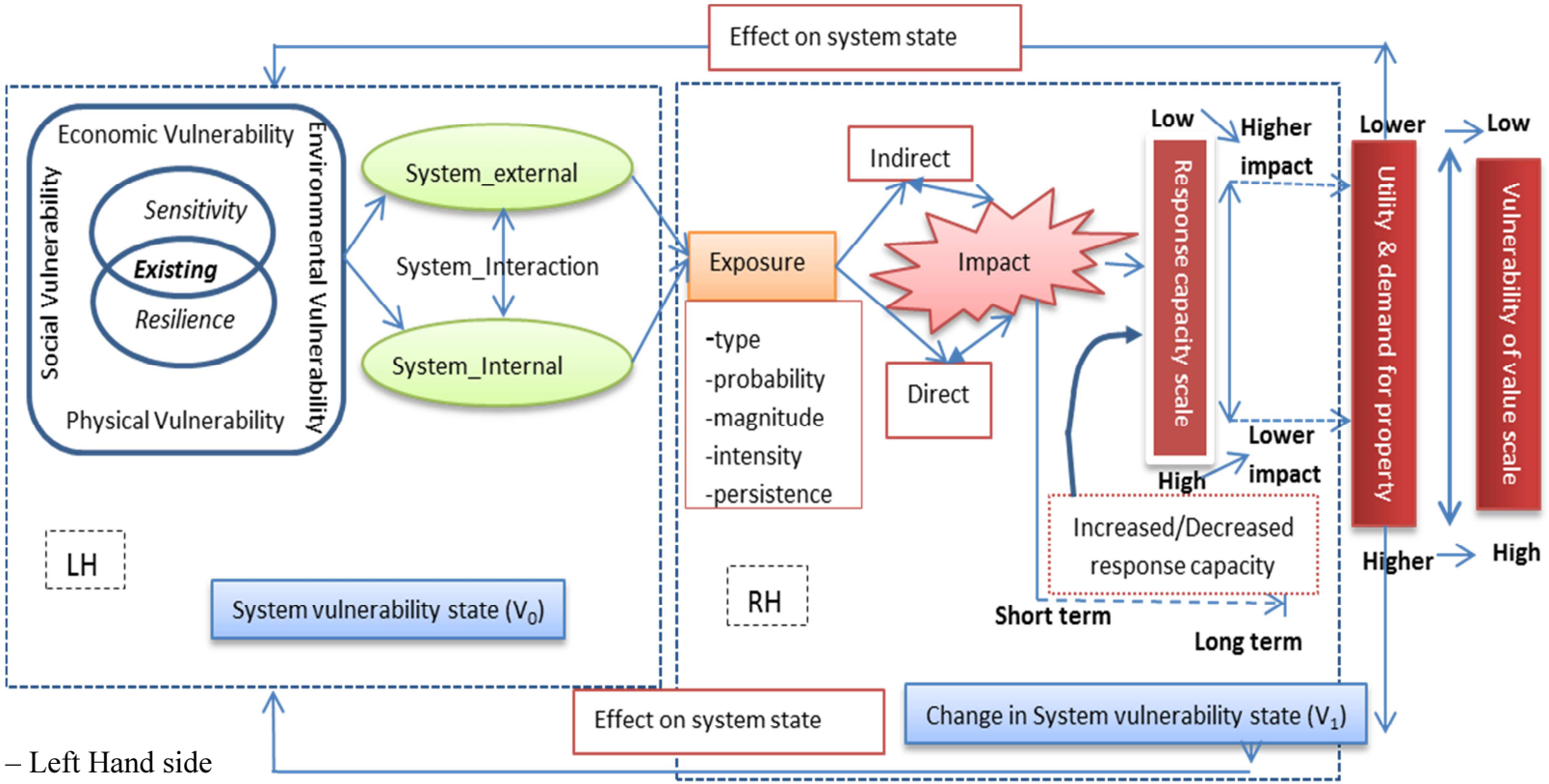
External factors such as legal issues, market fluctuation and locational factors can also add to the variability of vulnerability. Location of property (depending on the type of property) can have an influence on the business characteristics. For example if the property is at high risk of flooding and requires constant supervision for production and supply purposes as in manufacturing, construction or retail sectors, sudden disruption can cause interruption in the business operation. This can further limit the utility of the property. Other external factors like changes in market condition and economic environment can also affect market value of properties over time (Thompson & Strickland, 1996; Zhang, Lindell & Prater, 2009). These factors are directly or indirectly related to the utility of business property and the performance of the property in generating income. The utility and performance of commercial properties can be affected through short and long term revenue loss due to business closure, injuries to employees, damage to lifelines causing disruption in supply chain, and physical damage as a result of flooding. This contributes to total business revenue loss. Such losses can affect the total turnover and growth in business which subsequently can result in impaired value.

It can be observed from the conceptual maps that utility of property performance is hindered by exposed assets for both vulnerability towards flooding and vulnerability of property value. The amount of exposed assets determines the cost of damage as a result of direct and indirect effects of flooding. As mentioned before, adoption of mitigation measures can help in reducing the total cost of damage and therefore can have a positive effect on recovery time. There are factors which are common among the two conceptual maps. The common factors are the structural characteristics and business characteristics which impact both types of vulnerabilities. The intention is to highlight the link and develop a better

understanding of the dynamism of property utility in the context of flooding. Based on the illustrated conceptual maps it is now possible to determine the interrelationship between the factors affecting vulnerability of value towards flood risk. The discussion has also helped to develop an understanding of the dynamic system from its state of antecedent vulnerability to change in vulnerability as a result of flooding. The following section will detail the behaviour of the commercial property system and the processes inherent to the system. This represents the sixth step towards the development of the conceptual model.

4.2.3 Development of conceptual framework

This section discusses the theoretical base of conceptual framework on which the conceptual model of this research will situate. The first five steps identified the factors affecting vulnerability of business and value towards flooding and their interrelationships. It is now important to integrate the knowledge gathered from literature review and conceptual maps to give it a generic shape. The conceptual framework is generated based on existing information from literature following a systems approach. The framework is based on general systems theory which provides scope for explaining how the different factors affecting flood vulnerability and property value influence each other. System's theory in simple terms states that any dynamic system will be able to survive a certain level of environmental challenge only if it has the capacity to respond at least equal to the challenges it experiences (Ashby, 1956). Commercial properties with their internal and external dynamic vulnerability factors and processes constitute the total system in this research (refer to section 2.4.2 in Chapter 2 for details). The basic indicators that significantly affect the vulnerability of commercial properties towards flooding are the amount of exposure, nature and type of assets and their level of susceptibility to cope with the shock of flooding (Bhattacharya *et al.*, 2013). The process diagram in Figure 4.4 represents the generic conceptual framework proposed as a simplification of reality and reflection of the generic representation of the above discussion. This generic framework will then be refined to appropriately reflect the operational need of the research.



LH – Left Hand side

RH- Right Hand side

Figure 4.4 Generic Conceptual Framework showing impact of exposure, impact, response and recovery on commercial property system vulnerability [published in (Bhattacharya *et al.*, 2013)**]**

Figure 4.4 indicate two conditions of the same system. The left hand side (indicated by LH in the figure) illustrate the first condition or static condition of the commercial property system. At this stage the system constitutes its own level of vulnerability without any effect of flooding. The system of commercial property has its antecedent condition or the initial state (V0) in space and time. This is the cumulative effect of existing physical, social, economic and environmental vulnerability as illustrated in the conceptual map (Figure 4.4). This state of antecedent vulnerability also constitutes the systems inherent sensitivity and level of resilience affecting the system's coping capacity.

The commercial property system can be affected by interaction between the internal efficiency of the system and external pressures (such as market conditions). The factors constituting the internal system are property and business characteristics. The external system conditions are contributed by market settings, dependence on other external systems, transport and supply environments that can financially affect the working of the internal system. This interaction between internal and external factors determines the state of a commercial property system at a particular point in time. The entire concept of vulnerability of commercial property and its coping strategy depends on how fast properties can recover from the stress of a flood event. Longer recovery times means there is higher depreciation of property utility and there may be subsequent impact on value. Returning to business as usual state for commercial properties, however does not mean that the property will go back exactly to its state of operation before the flood event but to a new state where it can survive the impact of flooding and continue to cope with a changed system state (Alesch, Holly & Nagy, 2001a). The proposed generic conceptual framework bases its assumption on such theoretical base.

The right hand side of the framework (indicated by RH in the figure) illustrates the second condition or the dynamic condition of the commercial property system. It is indicated by exposure of the commercial property system to variable levels of hazard. When the system is exposed to certain impacts the effects can be direct or indirect. The direct effects on the system happen by means of damage and

disruption of property and business by direct contact with flood water. Alternatively, indirect effects can occur through business closure, demand and supply and lifeline disruption. Therefore the system is both directly and indirectly vulnerable to flood impact.

The effect of impact is largely determined by the type and characteristics of the event, its probability of occurrence, the magnitude and intensity of its effects and the persistence at which it continues to cause damage. This brings a change in the original vulnerable system state (indicated by V1 in Figure 4.4) at a certain point of time. The consequence of the change in vulnerability level can be observed in the short term or long term. This is determined by the time taken by the system to recover from the effect of disruption. The intensity of vulnerable system's state depends upon the system's capacity to cope and respond to changes. This coping capacity of the system is indicated by the response capacity scale shown in figure 4.4.

The response capacity scale of a system is directed by its level of resilience. When flooding occurs in the short term the commercial property system will cope depending on the existing level of resilience. As soon as the flooding occur the recovery actions are started. However, in the long term, there can be two options. Firstly, the system may improve its response capacity by adapting mitigation measures and prepare itself to reduce damage in the future; or the system may do nothing (decrease system response capacity) and deal with the situation at an ad-hoc basis. The first step may help the system to reduce its level of vulnerability for future flood events. The second option can actually reduce the systems response capacity in the long run and make it more vulnerable. This is especially important for commercial properties affected by repeated flooding. Faster recovery from flood impact is important for business operation and property utility and can have a direct impact on vulnerability of value.

Finally, the vulnerability of value on the framework illustrates the changes in value as a result of reduced utility of commercial property. The link between response capacity and vulnerability of value is determined by utility and demand for

property. When the capacity to respond against flooding is low the impact to the system is high and the system takes longer to recover and vice versa. This reflects the demand for the property in the real estate market among both buyers and those interested in renting properties. Demand for properties located at high risk of flooding might be more vulnerable to the changes in the system as a result of the existing stigma that the utility of such properties might have. The effect of changing levels of response capacity might not be reflected immediately on utility and demand for the property, but in the long run it might show some effect on the property value. The vulnerability of property value is represented in the framework as a scale to illustrate the relative degree of change within and outside the system and their effect in space and time.

As mentioned earlier flooding is one of many other factors that can have an impact on property value. This aspect provides the conceptual framework a scope for refinement due to the presence of uncertainties in the system. The change in vulnerability within the system due to flood risk, feeds back to the original system state. This brings in new changes within the system which are incorporated during the system recovery. This new system state now constitutes its own level of sensitivity and resilience with antecedent levels of vulnerability. The vulnerability chain is affected by the perturbations in the system. The total system remains unstable until balance between exposure, sensitivity and resilience is restored and the cycle continues with repeated impacts of flooding.

4.3 PROPOSED CONCEPTUAL MODEL

The seventh step towards development of the conceptual model is to design the conceptual model based on the identified theoretical framework. Literature decribe conceptual models as qualitative representation of a system which depicts the preconceived ideas and notions of how the system works (Mulligan, 2004). The representation can be paper or computer based. One of the most common representation of conceptual model is in a graph where the system components are represented by nodes and relationships are presented by multi directional arrows. The system consists of all the components identified through literature and the

structural relationships indicating dyanamism of the unit. The conceptual framework in the previous section illustrated the inherent systems theory associated with the system vulnerability of commercial properties. The dynamic process shows the flow path of disaster stress through the commercial property system in the form of changing levels of vulnerability. The conceptual maps in the sections before identified the factors affecting the change in business vulnerability and vulnerability of value. In this step the theoretical aspects and factors affecting vulnerability are brought together in the form of conceptual model to help in conceptualising how risk of flooding can have an impact on vulnerability of value. The conceptual model is systematically developed to relate the various components of the previously described conceptual maps and generic conceptual framework (Figure 4.5). the model will be subsequently used for generation of questionnaires and collection of primary data from the selected areas of study.

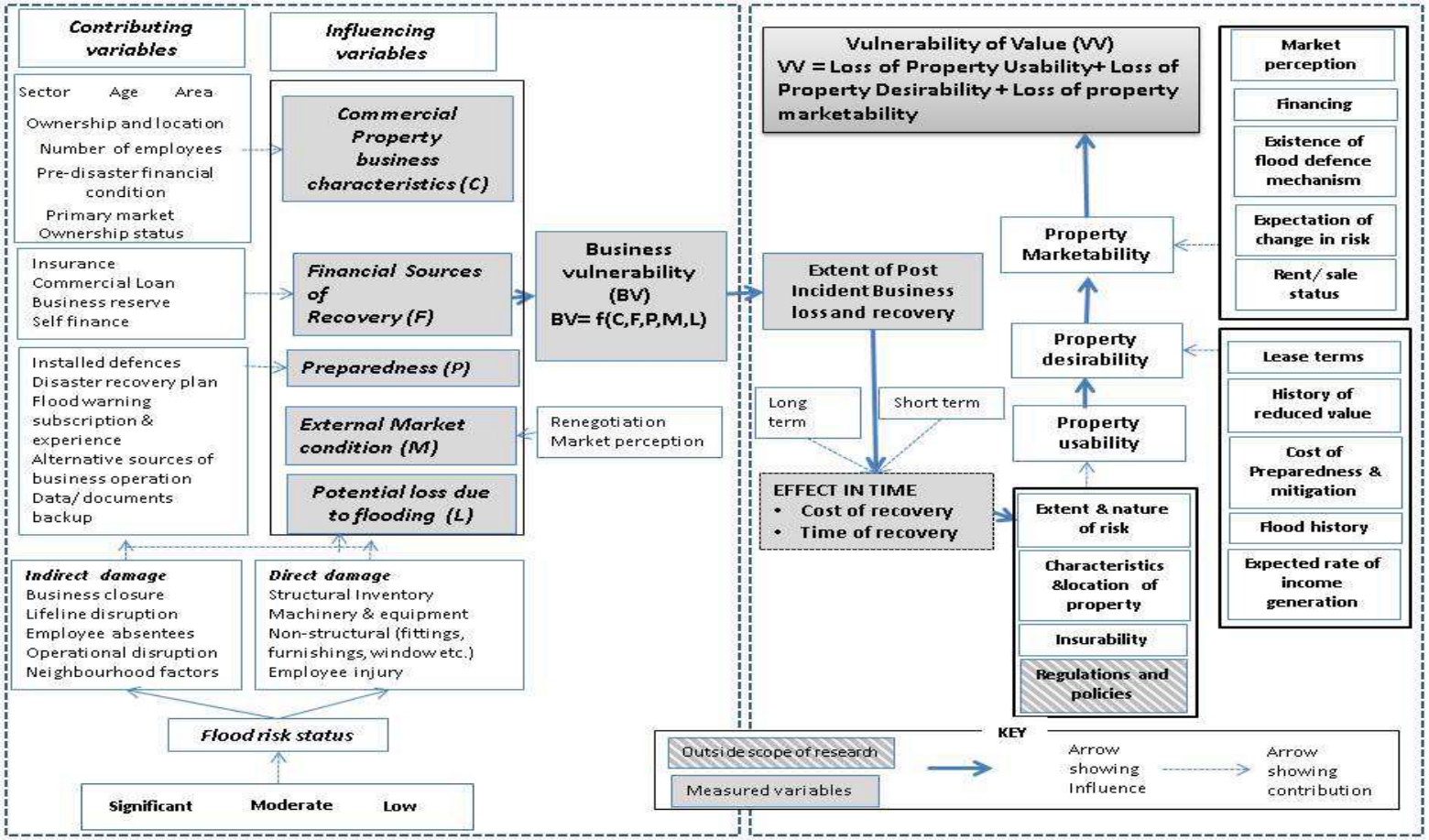


Figure 4.5 Conceptual Model indicating interaction between vulnerability of businesses and property value [published in (Bhattacharya *et al.*, 2012)**]**

The generation of this conceptual model help in representing the real world scenario. The operationalisation of this model will lead to the development of instruments for collection of data, analysis and interpretation. The conceptual model proposes that business vulnerability emanating from pre-flood situation can give rise to cascading effect on property value. The model clearly identifies the underlying determinants of the vulnerability of commercial property businesses and which determines the knock on effect on loss of income and marketability. The subsequent impact of flood on value is expected to be caused initially by a flood event. Consequently this exposure of the elements at risk which in this case are the commercial properties, leads to economic risk affecting the income generation and loss of marketability of property. The conceptual model emphasises the relationship between contributing and measurable factors. The measurable factors for business vulnerability against flooding are shown by light shades of grey.The model also highlights the factors outside the scope of this research such as incorporation of government regulations and policy effects on commercial property value. The link for assessing vulnerability of value over time sit within the context of cost of damage and time of recovery.

The left hand side of the framework indicate the level of business vulnerability of the property by incorporating the five potential influential factors. They are loss due to flood occurrence, sources of recovery, characteristics of the property (physical and economic), level of preparedness against flooding, and external market condition. It is important for any business organisation to recommence the flow of income as soon as possible after disaster occurence. Each of the factors for business vulnerability are derived from finer components of the contributing variables illustrated in Figure 4.5. The speed at which business recovers from any environmental disaster and their vulnerability depend not only on the exposure towards hazard but also on the effectiveness of mitigation and preparedness actions undertaken before the event. In summary, business characteristics like age, sector, ownership, size, and primary market affect the rate of recovery and continuity of business. For instance, larger businesses have greater potential for getting back to normal business sooner than smaller businesses (Balica & Wright, 2010). This also

indicates the businesses access to financial sources (self-funding, loan or insurance) which enable them to recover quickly. Similarly, flood experience and higher level of preparedness can also help businesses to recover faster by limiting damage.

After the initial shock of flooding the major aspect that affects businesses with time is the external market condition. The right hand side of Figure 4.5 indicate the market situation and how the different factors of business vulnerability interact with each other to affect marketability of property. A number of variables appear on both the business vulnerability and the vulnerability of value sections (right hand side of the conceptual model) of the model indicating their contribution towards business vulnerability and cascading effect on vulnerability of property value. As noted above, the presence of flood risk will not automatically be followed by impact on property value. However, if the existence of hazard results in increased operating cost or extra investment to induce risk reduction, this might affect business vulnerability. Such changes in business vulnerability might then have some effect towards the vulnerability of property value by changing perception of risk in the property market. These factors are represented in the figure by property utility, property desirability and property marketability factors.

Property utility depend on the extent and nature of risk, property characteristics and level of property insurability (see section 3.6 for details). Desirability of property is affected by terms of lease, previous history of property price (such as reduction of value due to flooding), history of flooding, the cost of preparedness to reduce flood risk, and finally expected rate of income generation from the property. Further to utility and desirability, marketability of commercial property is determined by financing options, rental or sale status, market perception, existing level of flood protection if due diligence is undertaken and the expected change in risk situation. The three factors are interrelated in a way that the effect of disaster on utility of property results in a lack of desirability followed by reduced marketability of property (Vatsa, 2004). The variables identified for measuring the influencing factors are illustrated with separate boxes with no colours in the conceptual model.

Overall the conceptual model provides a systematic approach for bridging the gap between flood vulnerability of commercial properties and the property value.The identified measures from the model need both internal verification and external validation. Internal verification of the conceptual model, which is the next step in the design framework is undertaken by revisiting research needs while the external validation process is be undertaken by data collection and analysis from external sources.

4.4 INTERNAL VERIFICATION OF CONCEPTUAL MODEL

Verification of the model internally represents checking both model integrity and logic based on the research needs (Macmillan *et al.*, 2001). This represents each phase of design and component of model is representative of the aims and objectives of the research. In the eighth step of design the internal verification of the developed conceptual model is commenced by revisiting the research needs as indicated in the flow diagram (Figure 4.1). The purpose of the model was to show the interrelationship between flood vulnerability and commercial property values. The proposed frameworks have succeeded in outlining the flood vulnerability variables affecting commercial property value. Therefore, it can be established that the framework theoretically succeeded in serving its purpose and internally verified the model as the product of literature review. The outcome of the research is the conceptual model which is now ready to point towards external validation using data from the real world.

4.5 STRATEGY FOR EXTERNAL VALIDATION OF CONCEPTUAL MODEL

At present due to the conceptual nature of the model, it becomes difficult to come to a robust conclusion that property value will be affected by the selected variables. Therefore it is reasonable to propose an empirical external verification of the conceptual model. This is the final step of the model design which proposes scope for revision and refinement after external validation. This exercise will help in identifying whether the proposed conceptual model is reliable for explaining factors affecting commercial property value. The viable means of assessing vulnerability of

property value associated with flood risk is indicated in the conceptual model. It can be expressed by the following expression:

Vulnerability of property value = Loss of property utility +Loss of property desirability +Loss of property marketability (Equation 1)

The expression consists of exposure factors based on events of risk, responses and outcome of responses in the form of property utility, desirability and marketability. Before the expression is applied for analysis it is important to provide a detailed consideration of the associated factors. From the adapted vulnerability expression (Equation 1) utility of property plays an important role in understanding exposure. In this case the property is subject to differential hazard determined by nature and extent of the phenomenon. The property characteristics add to the level of vulnerability, while preparedness factors help in determining the dynamism of reduced utility of properties.

The conceptual model is developed to identify the required indicators for primary data collection process. Assessment of loss of utility, desirability and marketability of property will be undertaken by collecting data related to associated factors indicated in the conceptual model. Hazard characteristics, risk reduction strategies taken by property owners and cost of such preparedness will be an essential part of the investigation. The expected levels of income generation and perception of property occupiers will also be incorporated in the verification process. Finally, marketability factors which primarily involve market perceptions of value of property will be investigated from the collected data. The next chapter will explain the research methodology and the process of data collection in detail for external validation of the conceptual model.

4.6 CHAPTER SUMMARY

This chapter has presented the sequential development of the conceptual model of vulnerability of property value. A model for assessing the changes in level of business vulnerability and corresponding property value based on flood risk has been proposed. The different contributing variables in the conceptual model which were later used to collect primary data from the selected case study areas reflects

upon the systems view of describing impact on the vulnerability of value illustrated by conceptual maps and the corresponding conceptual framework. The model takes into account the issue of lack of access to commercial property market transaction data and proposes an alternative method of investigating vulnerability of property value. It also emphasises the importance of developing a methodology which incorporates specific characteristics of the commercial property sector in determining vulnerability. The outcome from this chapter represents achievement of the objective 3. Progressing from the conceptual output, the next step of the research design is the selection of appropriate methodology for data collection. Thereafter, exploration of data will help in observation of patterns of response of commercial property towards flooding. In the next chapter a robust research design will stipulate the philosophy of the research, the research methodology, the data collection and analysis strategy to achieve the implementation of this conceptual model.

CHAPTER 5. RESEARCH DESIGN AND METHODOLOGY

5.1 INTRODUCTION

The chapter presents and explains the detailed research design and methodology adopted for the research. The review of the literature provided the necessary insight into the dimensions of vulnerability and property value. The strategy for the development of the conceptual model is detailed is the basis of the adopted methodology. This approach identifies the various themes from the literature and leads through the construction of conceptual framework, internal and external validation. The resulting design comprises development of the conceptual model and its validation through quantitative data collection in two different case study areas in the UK. Justification of the quantitative survey incorporating a case study approach is provided. The chapter describes the strategy of exploitation of the data to perform situation analysis of commercial properties in the selected study areas and validating the conceptual outputs of the model using the collected data.

5.2 PHILOSOPHY OF RESEARCH

The rationale behind having a robust research philosophy is that research is conducted through appropriate methods that are logical and systematic to the research problem. Literature propose three major elements that define design of research strategy: knowledge claim or methodological paradigm, strategies of enquiry and research method (Creswell, 2003).

Epistemology is the term used for understanding the theory of knowledge gaining from a philosophical perspective. The two extremes of epistemological stance lies on positivism (also known as ‘realism’ or ‘objectivism’) which assumes that reality needs to be measured through objectivity in a value free environment with researchers taking the role of an independent observer (Saunders, Lewis & Thornhill, 2009; Easterby-Smith, Thorpe & Lowe, 2002). On the other extreme of the continuum lies Interpretivism (also known as ‘idealism’ or ‘subjectivism) which argues that treating human beings like natural objects is not appropriate thus bases its assumptions on subjectivism such as perceptions and human nature rather than any

predetermined structure (Easterby-Smith, Thorpe & Lowe, 2002; Collis & Hussey, 2003).

The aim of this research is to identify the impact of flooding on vulnerability of value of commercial properties by integrating two different themes of flood vulnerability and property value. Based on the research questions the research is positioned in between the two epistemological extremes with slight inclination towards Interpretivism. Interpretivism or pragmatism assumes the capacity of the theory to solve human problems (Pansiri, 2005; Powell, 2001). Pragmatism takes into account practical judgement to deal with the problems as they arise. Therefore, taking into account the practical views and judgements this research leans a little towards Interpretivism in order to gather better understanding of the perception of human subjects.

To find the means to understand the issues of concern, it is also necessary to identify the means to find, order, analyse and exchange information and knowledge relevant to the issue (Cornwall, Guijt & Welbourn, 1994). Some researchers propose that methodologies are not totally dependent upon epistemology rather they are technical constructs to provide several methods to undertake different types of investigation to reach desired outcomes (Bryman, 1988; Silverman, 1985; Holborn & Harambolos, 1991). This pragmatic perspective was more adaptable for the purpose of this research as there is a clear interaction between the natural and human world. The argument here is that it is impossible to understand the knowledge claim without incorporating contingent beliefs, interests and projections. Perception and knowledge of behaviour of organizations also plays an important role in answering the research questions for this research therefore the inclination towards Interpretivism (refer to Figure 5.1).

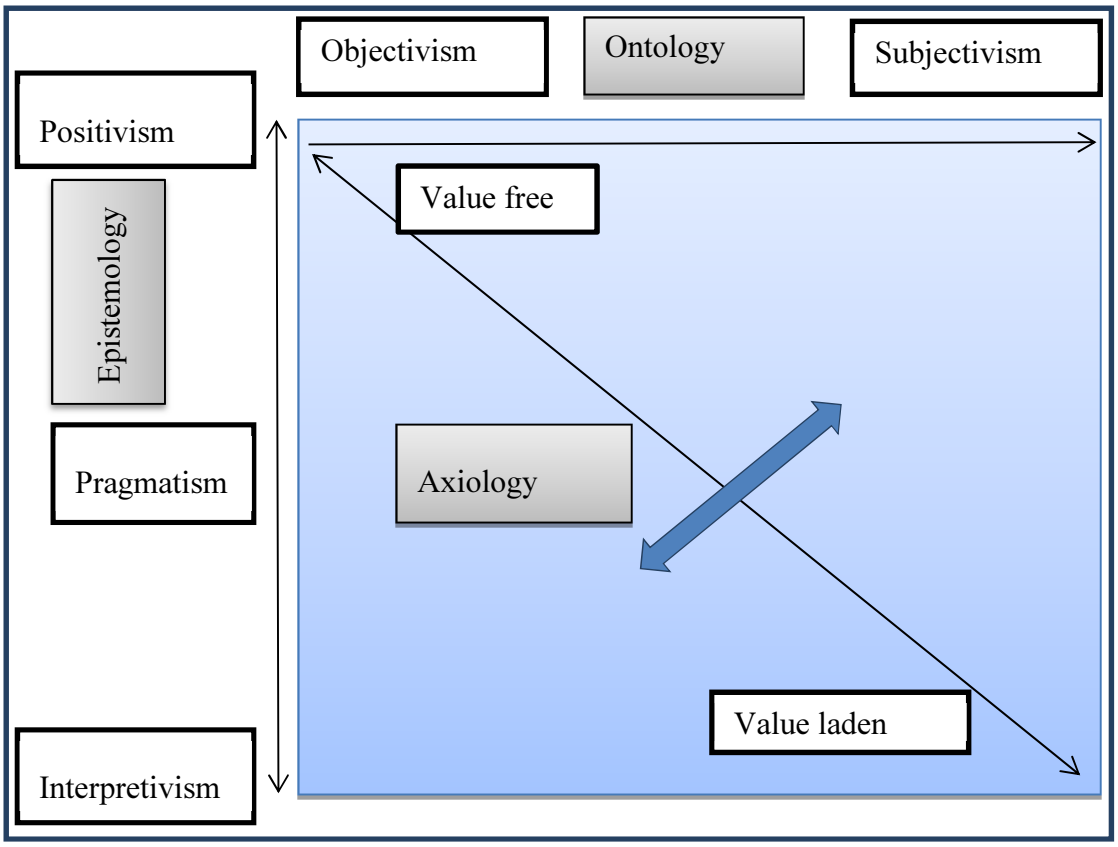


Figure 5.1 Philosophical stance of this research adapted from (Sexton, 2007)

The ontological stance is intermediate between objectivism and subjectivism. A balance between the two extremes is maintained where researcher's viewpoints, perceptions, analytical reasoning and logical deduction are also given importance for interpretation of information along with looking at reality through a contextual field of information.

Finally, the axiological stance is slightly leaning towards value laden research where the viewpoint of the researcher depends on what is the actual purpose of the research. The research values the complex understanding of the unique realities of human and environmental interactions. Therefore, the nature of research, the choice of methods, choice of theoretical framework, context of value resident within the system and the choice of format of presentation of findings all together directs the research to maintain a balance between complete value free and complete value laden research. With the existence of a number of subjectivities within the research it is evident that the axiological stance is slightly value laden.

5.3 APPROACH OF RESEARCH

Traditionally, the two alternative paradigms in research approach are induction (developing theories based on empirical observations rather than proving hypothesis) and deduction (development of theories with rigorous empirical testing) (Dainty, 2008). Deductive method comprises of conceptual or theoretical structure from existing knowledge and tests it through empirical evidence, that is starting from a general aspects and arriving in specific contexts (Collis & Hussey, 2003). In-spite of its problems of operationalization of concepts and subjectivity of human action, part of this objectivist deductive approach to enquiry is suitable for this research. Contrary to the deductive approach, the inductive approach specific aspects are studied to arrive at a generalised context (Creswell, 2003). Deductive reasoning is adopted to develop a conceptual model using a synthesis of available literature. Specific issues were identified through deductive approach which was later studied in depth via empirical data collection to support the driving deductive nature of this research.

The strategies of methods based on the above mentioned paradigms are again rooted in two different domains of quantitative and qualitative research approaches. There are several criticisms in application of quantitative or qualitative dichotomy, these methods are useful providers of framework that offers researchers with a choice of adoption between different strategies and methods (Creswell, 2003).

Quantitative research strategy consists of rationale for verifiable knowledge. In this type of methodology, knowledge is only considered to be reliable when they are constructed based on empirical reality (Creswell, 2009). The post-positivists emphasized the deterministic approach of 'cause and effect' relationships in social problems which helps in appreciation of objective reality (Creswell, 2009; Winter, 2000). It is possible to attain such objectivity by application of rational methods like careful observation and measurement (Glesne & Peshkin, 1992; Creswell, 2003). The two different methods commonly adopted by quantitative research strategy are: experiment and survey methods.

The development of qualitative research strategy about emerged as an alternative to the traditional quantitative research strategy. There are several methods for qualitative research: Qualitative research has been regarded as naturalistic, holistic, inductive and interpretivist in nature (Clarke & Dawson, 1999; Patton, 1999). Several approaches of qualitative research are identified in literature (Creswell, 2007, 2009). Unlike quantitative research, the qualitative research strategy emphasize not only on single objective reality but believes in multiple and dynamic transactions of subjectivity and objectivity taken together (Barone, 1992). Argument has been posed by qualitative social constructionists that being detached from the subjects of study to avoid bias as emphasized in quantitative research cannot provide fruitful results, since it is imperative to get close to the subjects of study to get their actual viewpoint (Clarke & Dawson, 1999).

Every approach has its own merits and demerits. However selection of a research approach for a particular type of research depends on the nature of the phenomenon under investigation, resource, time availability, experience of the researcher and most importantly the research problem (Creswell, 2003, 2009). This research aims towards better understanding of relationship between vulnerability of commercial property value towards risk of flooding. In quantitative terms, this indicates the relationship between factors affecting commercial property vulnerability and property value with reference to flood risk. The task involves quantifying the data collected from the real world for the themes of flood vulnerability and property value as discussed in the literature review sections and verifying the conceptual model outputs. The research has driven from the onset by the search of measures that can quantitatively represent the hazard, risk and perception oriented data related to vulnerability. This dictates the choice of a largely quantitative approach and research method as the foremost paradigm of this research.

Based on the above discussion the quantitative method of research is more suitable to achieve the aim for this research. The selection of methods is largely dependent upon the research type and match between problem and approach, therefore quantitative research strategies best suits the research concerned. The research adopted a suitable framework based on review of extant body of literature

and devised a conceptual model with connected measurement variables. Based on the insight gained from the research philosophy and approach the following section will describe the strategy of enquiry for the research adopted in obtaining the research aim and objectives.

5.4 STRATEGY FOR ENQUIRY

The enquiry strategies are determined by the problem rather than methods. The decision of choosing an appropriate research strategy depends on the type of information needed to be gathered and availability of resources. Literature in previous chapters suggested the complexity in the nature of vulnerability. The conceptual model showed the dynamic process of flood vulnerability on businesses and the property value. The model represented an important progression towards bridging the knowledge gaps relating to vulnerability of commercial properties towards flooding and its influence on value. Complex matrix of variables for vulnerability of businesses and their value are associated with flood risk category, impact details, recovery time and financial sources, level of preparedness, and perception towards influence of flood on property value.

Since the problem of investigating vulnerability is complex, it requires predictive judgement; the enquiry strategy of investigating vulnerability needs detailed breakdown. Figure 5.2 illustrates the proposed enquiry strategy for understanding the process of vulnerability. The figure shows the steps right from the beginning of the research which shaped the strategy of vulnerability analysis for this research.

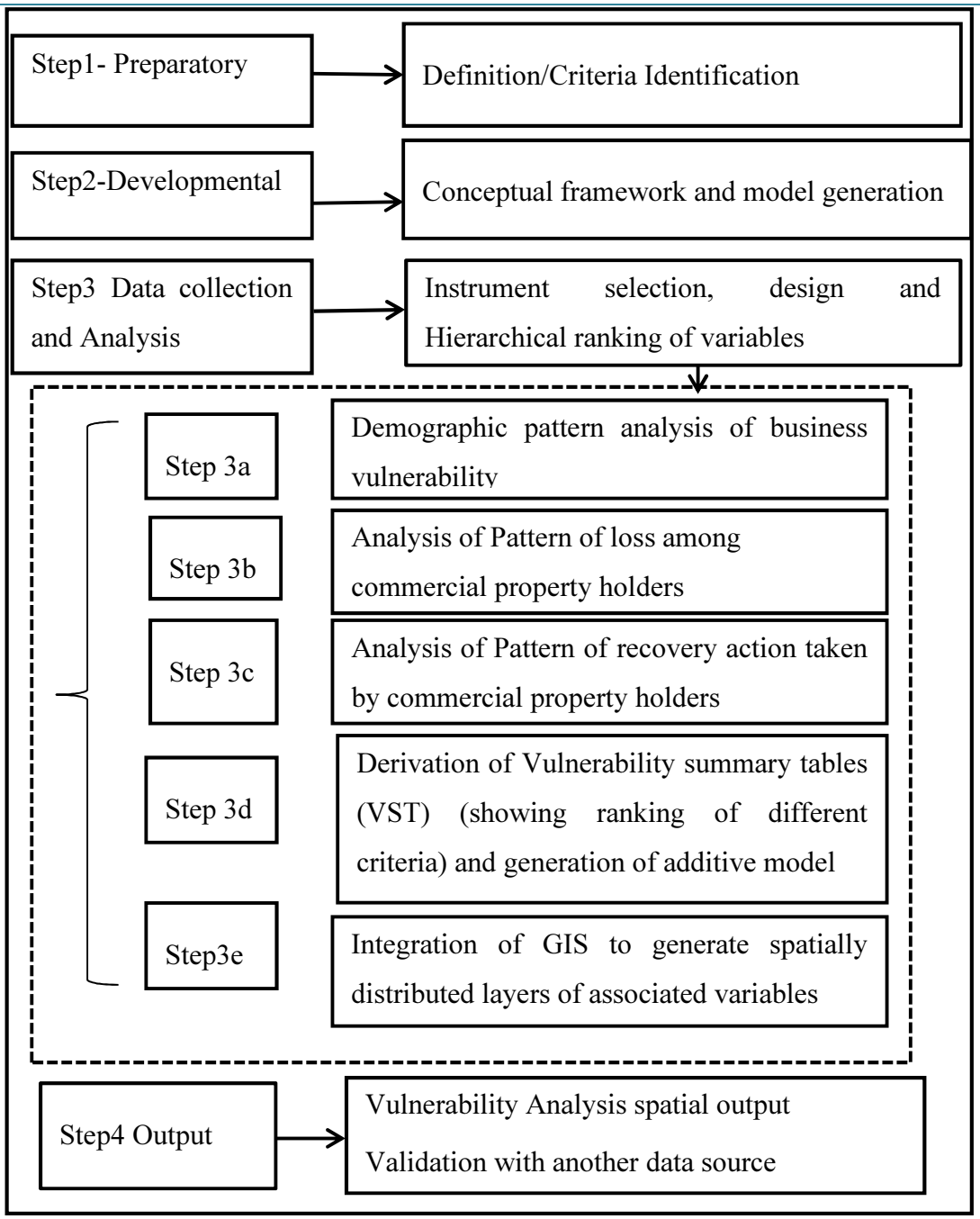


Figure 5.2 Phases of vulnerability analysis

The details of the various steps adopted in the analysis of vulnerability are described in the subsequent sections.

5.4.1 Step 1 and 2: Preparatory and developmental stage

The step 1 and 2 of the vulnerability analysis of commercial properties is the stage where preparation and development of conceptual understanding for the analysis. The preparatory step starts by defining criteria for analysis. This success of the vulnerability analysis depends greatly upon the preparatory phase. This stage has been explained in the literature review sections (Chapters 2 and 3) and continues up to the corresponding conceptual framework and model generation (Chapter 4) based on which the purpose of analysis is designed. The stage explains the necessary information, and the depth of information required for obtaining research objectives. The purpose of vulnerability analysis is to understand the broad view of vulnerable situation of the commercial property occupiers in the selected case study areas.

The identification of relevant stakeholders involved in the vulnerability analysis depended upon the purpose of the research. This research aims to identify the vulnerability of commercial properties and its cascading effect on value as a result of risk of flooding. Characteristics of business properties are important aspect of this vulnerability assessment. Therefore for overall understanding of the concept of vulnerability, it is important that investigation is done for commercial properties of various types, age in business, primary market area, type of lease and ownership patterns are captured. Furthermore, properties from different risk categories need to be investigated to identify spatial differences in their differential risk levels. Therefore commercial properties irrespective of their type and size in the three risk zones categorised by Environment Agency were chosen as appropriate participants for this research. Data collection instrument is designed accordingly and explained in the following sections.

5.4.2 Stage 3: Data collection and analysis

The development of conceptual model aided in building up the strategy for primary data collection. Based on the conceptualisation of links between business vulnerability and vulnerability of value the strategy for data collection was organised. The stage 3 of research plan consists of two parts: the instrument selection and design for data collection and analysis using hierarchical ranking and additive

model. The process of data collection include instrument selection and design, study area selection, sampling framework preparation, pre-testing and revising questionnaire, and finally administering the instrument in the selected study areas.

The second part is the analysis of collected data which is further divided into five steps as shown in Figure 5.2. Broadly, the first three steps involve understanding the nature and characteristics of samples collected for analysis of demographics of the samples. This is followed by investigating pattern of loss and of recovery actions undertaken by commercial property holders. The last two steps include ranking of different criteria associated with vulnerability, integrating them in GIS and finally illustrating their potential by generating vulnerability maps. The following sections will discuss the above mentioned steps in detail.

5.4.2.1 Instrument selection

This research demanded reaching out to a larger and geographically scattered population for understanding the actual situation on ground. The core research problem is flooding which is varied spatially and temporally. The research also required understanding of the perception of commercial property holders and their actions on issues related to flood hazard. Therefore, a process through which the participants can openly express their views was necessary.

Quantitative survey methods often use standardized questionnaires to measure perception oriented data such as thoughts, attitudes, feelings and behaviours of the samples drawn from a population as well as observational or factual data (Bulmer, 2004). Questionnaire survey design is a popular and one of the fundamental tools for acquiring information on knowledge and perception in natural hazard studies (Bird, 2009). Survey method provides opportunity to realise the objective of collecting different type of data at one go especially when the sample is large and geographically scattered. Hence, this research found the survey method appropriate for data collection. The various forms of survey instruments are those of self-completion of questionnaires by respondents themselves, face to face interviews, and responses via email or telephone. Self-completion of questionnaires seems more

appropriate for this research due to time and resource constraints and the large geographically distributed sample population in hand.

Postal surveys of this kind are useful not only for participation and views of large population but also to be able to reach appropriate samples. In this case a list of flood affected commercial properties is not available; therefore, the main challenge was to identify appropriate samples of commercial properties which are at different levels of flood risk. Postal questionnaires can reach to samples of diverse educational, social and economic background regardless of their level of technological literacy and therefore representation of the total population is expected to be well preserved. It is an effective way of collecting data from larger population of different risk zones where information is not available through other means at a much lower cost than other existing methods. Self-administered survey also helps to avoid interviewer bias, provides written records from larger population and is convenient for the respondents to answer.

A survey of businesses and organizations presents many challenges. It is important to bear in mind that business organizations differ in terms of their size, number of divisions, person responsible for administering different activities in different management level, and knowledge about the survey questions. Such complexities could lead to low response rate, which is not uncommon in disaster research (Muller, Reiter & Weiland, 2011; Bosher *et al.*, 2007). Researchers have advised measures such as sending reminders and cover letters which allows respondents to perform an informed choice to respond to the questionnaire to increase respond rate (Dillman, 2000; Oppenheim, 1992). Therefore these measures were adopted to enhance response rate for the survey.

Another criticism of using quantitative methods especially in self-administering social surveys is failing to understand the participants' intention while answering certain questions and imposition of meanings on social relations (Silverman, 1985; Oppenheim, 1992). Aspects such as poor construct of measures, in experience of researcher and weak external validity as a result of biased sample may also affect quality of questionnaires (Mitchell & Jolly, 2001). Quantitative research can also be affected by generalisation, replicability and individualism (Bryman,

1988; Nachmias-Frankfurt, C. and Nachmias, 1996). Therefore adequate care was taken during design of instruments for data collection and cross validation of research to reduce such bias as much as possible. In spite of the drawbacks indicated in literature this research structured its design around a quantitative approach. Data was sourced for gaining a wider knowledge of the population affected in different settings.

5.4.2.2 Instrument design

The first step towards instrument design was selection of measurement variables. In order to operationalize the conceptual model different specifications of data were required for understanding the various aspects of vulnerability towards value with reference to flooding. The variables selected for design of the survey instrument were identified through the conceptual model. Five categories of variables were required for the business vulnerability analysis namely: potential loss due to flooding; preparedness against flooding; availability of financial sources of recovery; characteristics of commercial properties to cope with changes in the system; and economic climate. Understanding vulnerability of value was dependent on the perception of commercial property holders towards existing risk. Therefore requirement was there to collect data associated with market perception of respondents. The first step was to select appropriate measures for each variable.

The required data is a combination of existing secondary data and collected primary data. The secondary data was obtained from Environment Agency and valuation office and primary data collected through postal survey. Direct measurement of all variables was not possible especially those associated with perception of people (Oppenheim, 1992). Therefore indirect techniques of assessment were adopted which is explained in section on global economic climate and perception of commercial property holders (section 5.4.2.7). The following sections will discuss the selection of measurement criteria (based on conceptual model) and development of instrument. The final design of the questionnaire can be seen in Appendix 4. The list of data required and their sources and types are shown in Table 5.1.

Table 5.1 Type and source of required data

Type of Data	Source	Data Type
Flood risk status	Environment Agency	Flood risk status layer in GIS format
Direct and indirect damage and disruption types	Survey questionnaire	Categorical data
Cost of damage	Survey questionnaire	Numerical data
Time of recovery	Survey questionnaire	Numerical data
Commercial property business Characteristics	Valuation Office Agency Survey questionnaire	Categorical, ordinal
Preparedness measures	Survey Questionnaire	Categorical
Preparedness measure (Flood Defences)	Environment Agency Survey Questionnaire	GIS format data [Shape (.shp file)] and Categorical
Financial Sources of preparedness	Questionnaire Survey	Categorical
Global and Local market Condition	Questionnaire Survey	Categorical
Market perception (with reference to risk and value)	Questionnaire Survey	Ordinal scale

As observed from the table different type and nature of data are required for the chosen investigation. The integration of different type and format of data in a model along with the strategy of analysis is described in details below. This step is the step three of the phases of vulnerability analysis (refer to Figure 5.2). The data collection of the measures would involve both identifying and collecting numeric information through the instrument. There will also be some options for open answers that will allow the respondents to include extra information and provide a general understanding of the situation in the study areas.

Certain aspects of qualitative research such as closer interaction with the subject are found suitable to this research; however specific data set which can help

in focussing at specific group of commercial property holders for in depth knowledge through observation or interviews wasn't available. Therefore further venturing in the qualitative domain was not possible due to lack of time and resources. The following sections will illustrate the way the above mentioned data were collected through the instrument.

5.4.2.3 Potential Loss due to flooding

The measures for potential loss due to flooding were sub-divided into two themes with several subthemes. Table 5.2 illustrates the different themes used for measuring potential impacts of flooding on business properties.

Table 5.2 Criteria for Potential loss to flooding

Themes	Sub-themes	Measure
Flood experience	Number of times flooded	Direct open question in questionnaire with 4 options and space for specification if the options does not match respondents' situation
	Source of flooding	Direct closed question with five given options and options to state other or no knowledge
	Awareness of flood risk	Direct closed question with three given options
Impact of flooding	Direct damage	Direct open question representing five dimensions of direct damage and option for stating if anything is missing
	Indirect damage	Direct open question representing six dimensions of indirect damage and option for stating if anything is missing
	Cost incurred for recovery	A twelve item scale was used to understand the variation in cost of damage for each item within a range of 1-5 where 1 representing no cost incurred and 5 having highest cost of damage.
	Time required for recovery	An eight item scale was used to understand the variation in cost of damage for each item within a range of 1-5 where 1 representing no cost incurred and 5 having highest cost of damage.
	Business interruption cost and time	Direct open questions for cost of damage and time for short term and long term recovery
	Effect on annual business turnover	Direct open question with options for no effect and some indicative percentage of effect on annual turnover.

5.4.2.4 Preparedness against flooding

The criteria derived for generation of measures for preparedness were embedded in four sub-themes: type of adopted measures, time when the measures were adopted, existence of community defences and effect of community defences. Table 5.3 shows the sub-themes and the measures adopted in the questionnaire to get information.

Table 5.3. Criteria for Preparedness against flooding

Themes	Sub-themes	Measure
Preparedness against flooding	Type of adopted risk reduction measures	Closed question with 13 options and space for specification if the options does not match respondents' situation
	Time of adopted measure	Closed question with two given options of before and after flood event along with every type of flood risk reduction measure
	Existence of community defences	Closed yes and no question
	Effect of community defences on flood risk	Two options with benefits from flood defences and open space for comments
	Effect of community defences on property value	A five item scale was used to understand the effect of defences on property value and 5 point Likert scale was used to get information about their level of agreement to the statements (1- strongly disagree and 5 fully agree)

5.4.2.5 Financial sources of recovery

The financial sources of recovery were distributed among two criteria: the type of financial sources adopted for recovery and the rate of recovery. Table 5.4 indicates the criteria involved in understanding financial condition of businesses.

Table 5.4. Criteria for financial condition of businesses

Themes	Sub-themes	Measure
Financial conditions	Type of financial sources adopted for recovery	Closed question with 13 options and space for specification if the options does not match respondents' situation
	Rate of recovery in terms of annual turnover, change in number of employees and customers	A 9 item scale was prepared representing three items for each time scale after recovery (1 year, 2 year and 5 year) and also for each dimension of recovery (annual turnover, employers and customers)

5.4.2.6 Commercial property business characteristics

Representation of measures for business property characteristics were divided into six categories: respondent's demographics and property type and nature. Respondent's demographics involved professional affiliation, company address; years of experience. Property characteristics included construction period of property, type of property, nature of property, .market status and lease terms which binds the property. Table 5.5 indicates the different criteria for business property characteristics.

Table 5.5 Criteria for Business Property characteristics

Themes	Sub-themes	Measure
Business property characteristics	Respondents demographics	Separate section with open questions on respondents' background information They were provided options to remain anonymous.
	Property type and nature	Closed questions on date of construction of property , use, market spread, primary customer area, ownership and lease terms

5.4.2.7 External market condition and perception

A general statement approach was found to be the most suitable in understanding the perception of respondents. As mentioned earlier it was difficult to

gain information about some of the aspects of perception directly, especially the economic climate and market perception; therefore while designing the questionnaire ample open spaces were provided to the respondents' to provide any additional information they would feel relevant to the individual questions. This practice helped in understanding the mind-set of the respondents later during the analysis phase. The theme areas for criteria like renegotiation and changes in property value straightforward questions were formulated. Table 5.6 illustrates the criteria involved in external market condition and market perception.

Table 5.6 Criteria for external market condition and perception of flood plain commercial property holders

Themes	Sub-themes	Measure
Renegotiation of contracts	Change in property value as a result of flooding and extent of change	Yes – no question with two options to choose from. Open space for comments and additional information. In case of agreement with change further option of extent of change in value was provided
Market perception	Property usability, desirability and marketability	Statement formation based on individual factors of usability criteria, desirability criteria and marketability criteria were provided in a 5 point Likert scale of agreement on sixteen statements (non-optional).

The market perception of commercial property holders (based on property type: manufacturing, retail and wholesale, service and all others) was investigated using a 16 item scale indicating property usability, desirability and marketability. Table 5.7 indicates the sixteen statements used in the questionnaire based on conceptual model to access commercial property holders' perception on flood risk and its impact on property utility, desirability and marketability.

Table 5.7 Criteria for market perception on property utility, desirability and marketability

Theme	Perception	How perception effects vulnerability of property value
Property usability	Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future	Respondents with higher agreement to such statements are expected to have less desirability to deal in high and medium risk properties as a result of their expected reduced utility, therefore value is more vulnerable
	Loss of income from flood risk affected properties can negatively affect the demand for such properties in the real estate market	Respondents with higher agreement to this statement are expected to perceive that with higher loss of income the properties will lose its demand in the market, therefore value is more vulnerable
	Prime location of property is a more important factor in determining property marketability than flood risk	Respondents with higher agreement to such statement indicates their perception towards risk is undermined by other factors of profit making and are willing to pay more for such properties, therefore value is less vulnerable here
	Easier availability of flood insurance can encourage business owners/ occupiers to opt for insurance against flooding	Respondents with higher agreement are expected to pay for insurance and therefore enhance property resilience and reduce risk, therefore value will be less vulnerable
	Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market	Respondents with higher agreement to this statement indicate that they are not willing to pay more for risk prone properties, therefore value is vulnerable
Property desirability	Once a flood disrupted property loses its value in property market it is difficult to get higher value for the property again	Respondents with higher agreement are expected to have the perception of stigma associated with flood affected properties, therefore they will not be willing to pay more for the property, therefore value is vulnerable here
	Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market	Respondents with higher agreement indicate that they are willing to pay for properties at higher risk because of flexible lease terms, therefore vulnerability of value of such properties is lower
	Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding	Respondents with higher agreement indicate that they perceive properties with higher income generation potentials are more desirable in the market even if they have higher probability of risk of flooding, therefore vulnerability of value of such properties is

		lower
	Properties with history of reduced value as a result of flooding always have low demand in the property market	Respondents with higher agreement indicate that once a property has experienced any negotiation in terms of flood risk, it becomes less desirable in the market, therefore its value becomes more vulnerable
	Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future	Respondents with higher agreement indicate that the respondents perceive that if the property is made resilient against flooding the value of the property will not be affected and desirability can increase in future, therefore vulnerability of value will be lower
Property marketability	Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market	Respondents with higher agreement to the statement are expected to pay higher for properties with resilient measures installed either on community basis or at property level, therefore vulnerability towards value of such properties will be lower
	Lowering flood risk by installing resilient measures does not affect property value in the long term	Respondents with higher agreement to this statement indicate that they are not willing to pay for long term resilience of the property and even with higher risk vulnerability of value of such properties will be lower
	More loss of income during flood disruption results in longer recovery time	Respondents with higher agreement perceive that flood disruption and longer recovery means higher loss of income therefore higher risk of getting back in business, thus higher impact on vulnerability of value
	Longer recovery time means higher loss of utility and income from the affected property	Respondents with higher agreement indicate perception that, with higher loss of utility of property value can be more vulnerable
	Suitability for mortgage finance makes a property more attractive in the property market in spite of its high risk of flooding	Respondents with higher agreement indicate that suitable finance has higher priority over flood risk in the market therefore vulnerability of value for such properties will be lower
	High flood risk and disruption of business encourages property occupiers to move out to a lower flood risk zone	Higher agreement indicates respondents are willing to move out of the significant flood risk area, therefore making vulnerability of value higher for those properties
	Agreement scale is divided between 1 and 5 where 1 indicates total disagreement, 3 indicates neutral view and 5 indicates total agreement. Therefore any agreement level over 3 is considered to be part of higher agreement and weighted accordingly. With perception of higher vulnerability of value highest weight of 1is assigned, followed by neutral agreements of 0.5 and for lower agreements a weight of 0 is provided	

5.5 SURVEY INSTRUMENT

Based on the above mentioned measures a survey instrument was generated. The questionnaire strategy was planned following the University of the Wolverhampton's ethical protocols. The permission for ethical approval was acquired for this purpose. Furthermore, a cover letter was printed on official letterhead with the name of the university, department, name of the researcher and the supervisors. The contact address of researcher as well as the School of Technology, University of Wolverhampton was provided to the respondents to seek clarification in case they were in any doubt. In the brief outline of the research which was attached with the questionnaire, the purpose of the questionnaire was mentioned emphasizing the nature of the research. The respondents were assured that just they should not be alarmed of flood risk just by receiving the questionnaire so that no unnecessary concern on the respondent will be created (refer to Appendix 3).

The confidentiality and anonymity of the participant's was maintained and confirmed to the participants. Reminder mails were sent to the total sample population to increase response. The approximate time required for filling up the questionnaire was also stated (20 minutes) (determined by taking the average time taken by 10 respondents during pre-testing of the survey instrument). A freepost return envelope was provided with the questionnaire for response. The pattern of enquiry for which the questionnaires were constructed was to conduct analysis of the attitude of the respondents (occupiers of commercial properties) towards a set of factors. The influencing aspects of measurement specifications like type and characteristics of the sample, approach towards the samples, their anonymity and so on are taken into account during the construction phase of the instrument. Based on the research design and conceptualisation of the research problem a comprehensive listing of each variable to be measured was included in planning the design for the questionnaire.

The survey instrument was divided into four main sections and some subsections. The section A of the questionnaire was intended to distinguish the sample population by their flood experience. This is done as there was no straight forward way to determine which samples are affected or unaffected by flooding. The

rationale was to get information from only flood affected commercial property occupiers of their experience of flooding. However, those respondents who were not flooded were also important for the study in order to gain understanding of their differential perception from those affected by flooding.

Section A was divided into part A and B. Part A collected event date, and number of times flooded since 1997. Although the 2007 event was the focus the time scale was extended to increase the probability of capturing more respondents with flood experience. In part B there is 18 questions related to flood experience, impact and recovery, preparedness and financial sources used for recovery. Flow of the questions are maintained reasonably well so that respondents find it easier to answer when they are remembering an old event. The third section of the questionnaire where all respondents are required to answer, deals with perception of market condition with reference to flooding and property value. Sixteen statements are framed to highlight how differential perception can have an impact on the level of vulnerability of potential change in property value.

Extra space was provided for respondents to express their views if they wanted to provide further information to what is already indicated in the questionnaire. This information was later used for understanding specific aspects of vulnerability such as global economic condition on property value qualitatively. Finally, the section D dealt with the demographic information about respondent and the business property in question. After the questionnaire was finalised, it was necessary to make sure that it is clear and easy enough for the respondents of different backgrounds to answer. This was undertaken by investigating validity of the questionnaire. The next section will discuss in detail the criteria associated with validity checks of survey instrument.

5.5.1 Validity of survey instrument

The main purpose of pre-testing or checking the validity of the questionnaire was to learn lessons and modify the instrument for the full stage survey. The second aim was to validate the questionnaire in terms of wording of the questionnaire, structure, length, clarity and ease of understanding. Ten members of the research

community from different backgrounds were asked to assist in validation of the questionnaire by completing it based on their knowledge and perception. The respondents were given full information about the research goal, purpose of the questionnaire, and the criteria of measurement that is expected from the questionnaire before they started. The purpose of this exercise was to provide opportunity to participants to make an informed decision when indicating the validity of the questionnaire. The questionnaire pack along with a cover letter was provided to all the respondents. The respondents were requested to point out any inconveniences or problems they faced while filling up the questionnaire. A separate sheet of paper was provided to each respondent where they were requested to indicate the time taken to fill up the questionnaire and the main difficulties faced while answering the questions.

The literature proposes four different types of evaluation criteria for validity of questionnaire. These are content validity, criteria validity, construct validity and face validity (Rubio *et al.*, 2003; Fillenbaum & Smyer, 1981; Bryman, 1988). Content validity essentially checks the operationalization of the instrument against the relevant domains for which it has been constructed. Face validity looks deeper into the construct and checks if 'on face' the contents have actually been translated to a meaningful construct (Trochim, 2006). Construct validity is defined as the approximate truth that the operationalization of the theory was reflected on construct of the instrument (Fillenbaum & Smyer, 1981). Criteria validity checks the performance of the instruments against specific criteria set. This is different from content validity because criteria validation is a prediction of the performance of the instruments in future on how the operationalization will work (Brinberg & McGrath, 1985; Trochim, 2006). A table of evaluation criteria for the questionnaire validity is added at the end of the questionnaire in Appendix 2.

Based on the responses some changes were made to the design of the instrument. The main comments indicated by the respondents were length and wording of some of the questions. On a scale of 1 to 5 where 1 indicate the question being not suitable at all, 3 indicate suitable and 5 indicate perfect. The respondents were asked to rate the questions on this rating scale for each question in the

questionnaire. The average value of the content rating scale was 4, followed by criteria validity 4.2, construct validity 3.8 and face validity of 4. Based on their comments and notes both verbally and in the answer sheet provided with the questionnaire required changes were made and the respondents were revisited to validate the changes.

Due to the complicated nature of the questionnaire and large amount of information expected to be gathered, reducing the length proved problematic. To maintain simplicity of the questionnaire in order to make it understandable to the intended population, reducing it would have made it more complicated. Equally, the time to complete, although fairly long at 20 minutes, was deemed acceptable given that non-flooded respondents would not have to complete the whole questionnaire and those that had been flooded were expected to have high interest and motivation to complete a longer instrument. However wordings were changed as advised. Once the questionnaire was approved by university ethics committee it was administered to a wider population. It is important to select appropriate sites for gathering data. It was impractical to include all flooded locations in the UK, therefore representative study areas were selected and questionnaires were administered.

5.5.2 Selection of study area and sampling of data

The national assessment of flood risks in England states that the second area after London at highest risk of flooding with largest number of people living at risk is Yorkshire and Humber region (Environment Agency, 2009b). The number of commercial properties affected by the 2007 flood in the region was approximately 3718 which is the highest in the entire country (Environment Agency, 2009b).Table 5.8 shows an estimation of the approximate number of business flooded in the 2007 flood event by Government office region. Therefore, it was decided that this area will be selected as the area of interest for the research.

Table 5.8 Effect of 2007 flood on businesses

Government Office Region	Number of businesses flooded
London	302
Yorkshire and Humberside	3718
South East	129
Welsh Assembly Government	4
East Midlands	290
West Midlands	1453
South West	1000
Total	6896

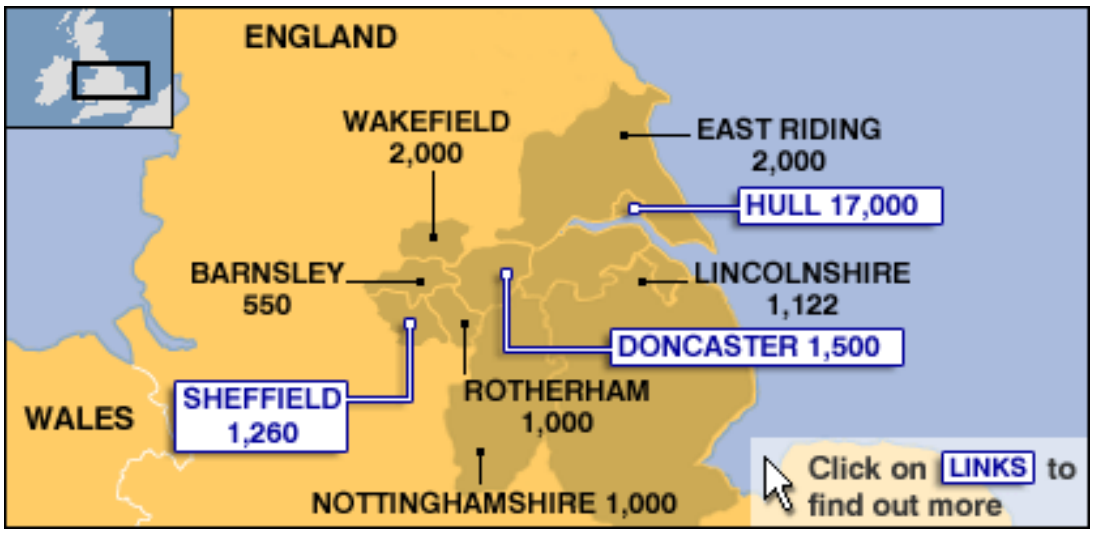
Source: Common recognised information programme 45, 24th October 2007 & Environment Agency Data (Common Recognised Information Programme 45, 2007)

Based on the above information two areas in Yorkshire were selected as the survey area of study; Wakefield in west Yorkshire and Sheffield in South Yorkshire (Figure 5.3). The factors criteria considered for selection of these two case study areas were: flood history, present and potential risk of flooding and existing flood risk for commercial property sector.

Figure 5.3 Map showing four regions of the county of Yorkshire

Source: http://www.focus-on-training.co.uk/funding/yorkshire_humberside_enhancement_fund/

Based on information obtained about the number of properties in worst hit areas from the news and relevant flood risk assessment documents just after the 2007 event the number of case study areas was reduced to four places: Wakefield, Hull, Doncaster and Sheffield (Figure 5.4). Sheffield and Hull were close competitors in terms of number of properties affected, however with a higher frequency of flood history and higher percentage of affected commercial properties, Sheffield proved to fit better for the purpose of this research.



Source: (http://news.bbc.co.uk/1/hi/uk/6277996.stm)

Figure 5.4 Worst affected areas of flooding in 2007

The selection criteria for the four study locations and given below with the reason for the two locations which were finally selected (Table 5.9). The selection was made based on the criteria indicated earlier. The action column shows why the area was selected and details column provides the information responsible for the action.

Table 5.9. Selection criteria for area of interest

Area	Action	Remarks
Sheffield	Selected (details in section 5.5.2.2)	1000 properties flooded in 2007 event and many more at risk. Factors like history of flooding, potential risk, number of properties affected were well matched
Hull	Was of high interest and nearly selected.	1300 properties flooded in 2007 event but Environment Agency data essential for the work was available for Sheffield
Doncaster	Not selected	Not enough businesses flooded or at risk of flooding, that is., most vulnerable areas are residential
Wakefield	Selected (Details in section 5.5.2.1)	History of businesses flooded and 794 properties at potential risk of flooding (based on 2007 flood)

The following section will describe the characteristics of the chosen study areas.

5.5.2.1 Study Area 1: Wakefield

Wakefield is situated in Western Yorkshire, England. Significant lengths of rivers (Calder, Aire and Dearne catchments) and watercourses exist in the study area which had given rise to flood risk problems in the past. The area was flooded four times in the last 15 years (1998, 2001, 2007, and 2008). Different sources of flooding for example sediment accumulation in the Calder, surface water flooding, sewer flooding and flooding from mixed sources in the built-up area also exists in the area (JBA Consultant, 2009). According to the strategic flood risk assessment published by Wakefield City Council, central Wakefield and its surrounding areas are affected by a high risk of flooding. Therefore, five postcodes in central Wakefield were selected for the in-depth study.

There are about 794 business properties at high risk of flooding (JBA Consultant, 2009). The entire population in flood zone 2 and 3 (890 in number) were selected for the 5 postcode districts (WF1 to WF5) as samples while in the lower risk

region (Flood zone 1) another 940 samples were selected to make the sampling strategy representative of the population. The total sample size was 1830. In the last few years some community level flood defences have been installed in this area; however their conditions until very recently were discontinuous and mixed. Therefore the expectation was to get comparative response from the selected sample population with different risk of flooding and its impact on vulnerability of businesses and property value.

5.5.2.2 Study Area 2: Sheffield

Sheffield is a city situated is in southern Yorkshire in England. The area has a long history of flooding and recently suffered in 2000, 2007, 2009, and 2012. The Sheffield area is delineated into three fluvial risk categories of flooding, for example, low, moderate and significant risk zones indicated by zone 1, 2 and 3 by the Environment Agency. There are a number of other sources of flooding besides fluvial flood in the area. There are evidences of localized flooding, for example surface water flooding, underground sewer surcharge and local gullies and culvert blockages (SFRA, 2008). This situation can be exacerbated with excessive rainfall such as the event of 2007. The distinguishing feature of flooding in Sheffield in 2007 was the sheer volume, force and speed of water coming down the river in a very short period of time (SFRA, 2008). There were approximately 1000 businesses flooded in this event. The M1 motorway was shut for days indicating vast disruption in supply of goods and services to and from the area. Yorkshire Electricity Distribution Company indicated that there were power cuts in the area and problem of water supply. According to the strategic flood risk assessment published by Sheffield City Council, surrounding areas of post codes S6 and S35 are affected by a high risk of flooding and have previously been flooded (SRFA, 2008). Hillsborough and Chapel town are the two areas located within these postcode areas which were worst affected by the two occasions of flooding 10 days apart. Therefore, the two post codes S6 and S35 were selected for questionnaire distribution. The same number (1830 total) of questionnaires were circulated among flood zone 2, and 3 (288 in number) and flood zone 1 (1542 in number) for representative sampling in all risk zones.

5.6 DATA EXPLORATION AND ANALYSIS STRATEGY

This section describes the strategy of analysis of the information collected through the data collection stage. The strategy of data collection and analysis is commenced in sequences aiding each level of analysis build on the previous step. The collection of primary and secondary data was undertaken in two phases. The secondary data was collected from Environment Agency and Valuation office website and then based on the secondary data the primary data collection was implemented as described in the previous sections. Figure 5.5 illustrates how the combined effect of data from primary and secondary sources helped in attaining the data analysis and model building stages. After the outputs from the vulnerability models were attained, validation of the findings was achieved.

Preliminary data exploration and analysis was undertaken on the collected data from questionnaire. Descriptive statistical analysis was undertaken to explore the patterns in the data. Data exploration further helped in analysing and arranging results for subsequent linkage to the vulnerability models. The following section will firstly explain the approach for exploration of quantitative data and elaborate the strategy adopted for business vulnerability of commercial properties towards flooding and its cascading impact on vulnerability of value analysis.

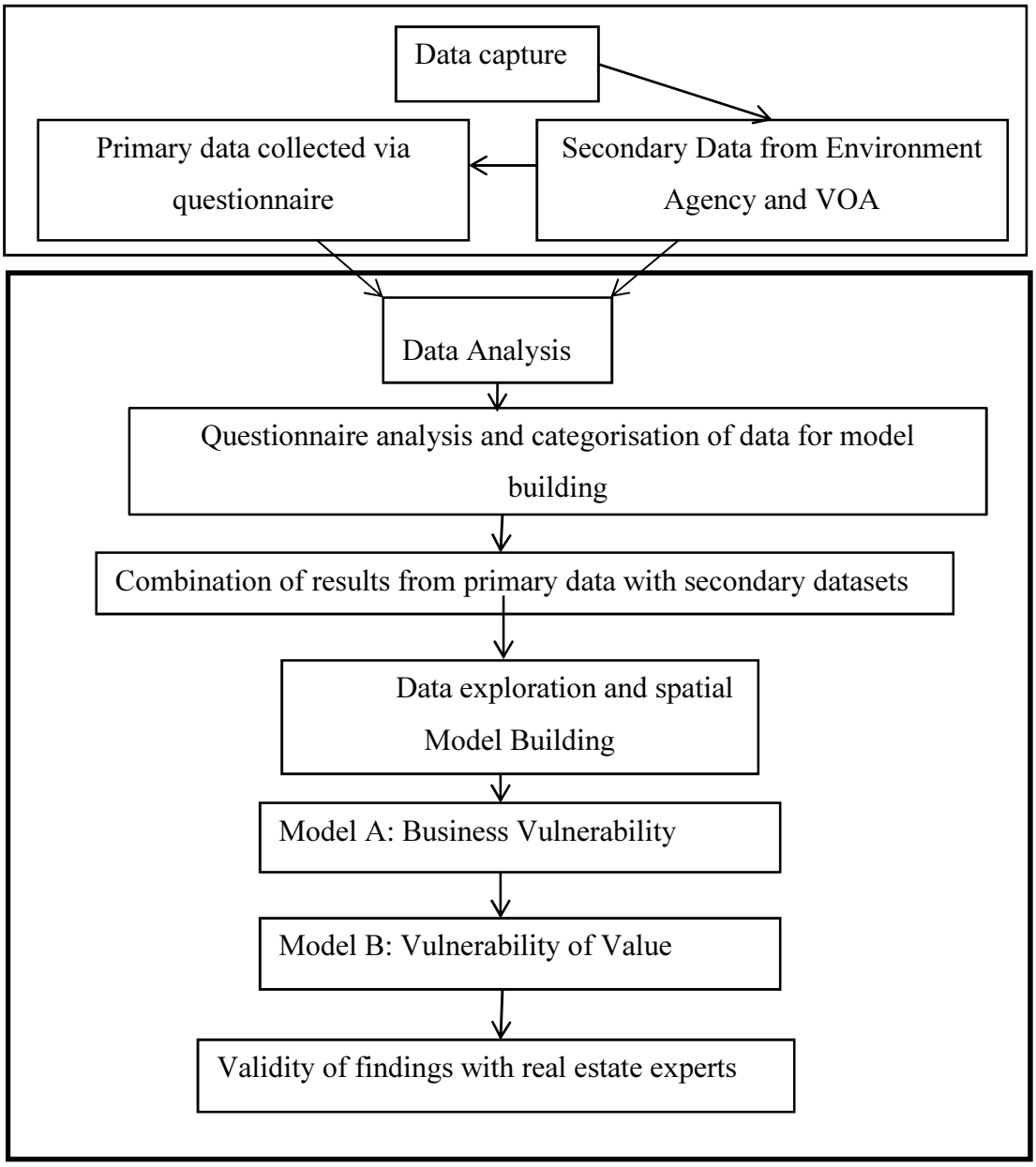


Figure 5.5 Data analysis strategy

5.6.1.1 Descriptive statistics

Descriptive statistical analysis on the quantitative data collected through questionnaire survey was undertaken. The understanding of nature of collected data and exploration through use of descriptive statistics such as mean, median, mode, and standard deviation were employed. For the purpose of analysis Microsoft Excel 2010 and SPSS 19 were used. Exploration of data using these descriptive statistics was important for understanding the suitability of the data for the purpose of further

analysis. As the validation of the conceptual model is largely based on the primary data obtained from the sample population, the level of experience and knowledge among the respondents was important for research credence. Descriptive statistics was used to explore the data to obtain understanding of flood loss and preparedness. Median values were taken to represent summary of data identified by occupiers especially where agreement levels were analysed. It was also important to have an evidence of the agreement among raters (participants providing ranks for perception criteria) to see whether the median values representing the different criterion can be interpreted for further analysis with confidence.

5.6.1.2 Agreement test

Measurement of the agreement among the respondents was required to demonstrate the responses obtained from respondents are more similar to each other than would be expected by chance (Klein, Dansereau & Hall, 1994). The degree to which ratings are similar in level and magnitude within a group is determined by the inter-rater agreement technique. This is distinct from inter-rater reliability which determines the similarity or consistency of pattern of responses between two or more raters. The main difference being, the quality of inter-rater agreement index to 'reference the interchangeability among raters, it addresses the extent to which the raters make the same ratings' (Kozlowski & Hattrup, 1992). Therefore inter-rater agreement was appropriate for identification of agreement among raters for each item to be investigated.

The measure of assessment found appropriate for the study was inter-rater agreement index rwg (James, Demaree & Wolf, 1984). The rwg index was criticised as an inappropriate inter-rater agreement index as rwg was primarily proposed to be a reliability index (Schmidt & Hunter, 1989; Kozlowski & Hattrup, 1992). As suggested by critics and later re-casted by authors that the appropriateness of rwg as an inter-rater agreement index remains the same with its all original definitions and scaling, except for the labelling of the index as inter-rater reliability index to inter-rater agreement index (James, Demaree & Wolf, 1993). The inter-rater agreement deals with the observed variance of the rating variable x. When the raters of the variables are in complete agreement then the error variance (S^2_x) is supposed to be

zero (0). However, for errors in measurement it generates an error variance of $S^2_x > 0$. Furthermore, to understand the degree of variance a benchmark was required for comparison which was estimated in literature to be due judgements exclusively to random measurement errors referred as expected variance (α_E^2) (James, Demaree & Wolf, 1993). After rescaling the ensuing equation used for the agreement index is $r_{wg} = \frac{\sigma_E^2 - S_x^2}{\sigma_E^2}$

alternatively, $r_{wg} = 1 - \frac{S_x^2}{\sigma_E^2}$ Equation 2

Where S^2 = Observed variance in ratings

$\sigma 2$ = Variance of null

1 = Perfect agreement

0 = Absence of agreement

There are certain debates in literature around choice of rwg as an interrater index over other available indices. However, it has also been established that this is premature to justify using one type of inter-rater indices over another for inferring level of agreement (Cohen, Doveh & Nahum-Shani, 2009). The interpretation of rwg as greater than >0.7 was conventionally considered to be representative of good agreement (James, Demaree & Wolf, 1993). Nevertheless, later researchers indicated that the thumb rule of >0.7 does not always perform as a good indicator of agreement because this value varies substantially according to sample size of rater group (Cohen, Doveh & Eick, 2001). Therefore the interpretation based on sample size of the present research is undertaken for agreement analysis. For the present study the importance of measurement of inter-rater agreement index is to establish the unit level constructs of psychometric properties (perception criteria) and test the logic of construction of conceptual model. After the agreement analysis was undertaken, the criteria were set for analysis of vulnerability of value.

5.7 BUSINESS VULNERABILITY & VULNERABILITY OF VALUE

In economics it is important to identify empirical traceability of analysis however, for certain types of vulnerability comparability using common metrics of empirical analysis is difficult, such as vulnerability to inadequate education, social unrest and several elements of social concerns. Proxy for analysis of such factors can be used but limitations for such proxies were also noted. Vulnerability is also considered to be the stage when the minimum level of socially accepted reference point cannot be attained (Alwang *et al.*, 2001), however there may be concerns over conflicts on setting the threshold for achieving minimum level to be not in a stage of vulnerable. Therefore the logical consequence was the need to measure probability associated with future states of systems to compute current level of vulnerability (Ravallion, 1996). The literature indicated a comprehensive set of variables (criteria and sub-criteria) requiring integration to generate total vulnerability.

The structured hierarchical approach seemed appropriate to provide a comprehensive view of the nature of the problem. The hierarchical process allows representation of all the factors in a stepwise manner at different levels. The process also allows different criteria of vulnerability to be equally represented and reduces bias and subjectivity (Actionaid, 2005). Several studies in the field of water resource planning, natural disaster risk assessment, urban flood hazard planning, and participatory decision making research including multi criteria analysis studies found hierarchical modelling suitable for their purposes (Willett & Sharda, 1991; Du & Lin, 2012; Fernández & Lutz, 2010).

The heart of this analysis is a generic criteria tree containing weighted additive sets of criteria and sub-criteria with their potential contribution to total vulnerability. The generic criteria tree designed for business vulnerability based on literature contains three levels: level 1 indicating the main objective of analysis, level 2 the criteria of analysis and level 3 the sub-criteria for analysis. The objective is measurement of vulnerability of businesses with response to impact of flooding. This objective is then divided into five criteria which can have differential impacts on the level of business vulnerability (Figure 5.6).

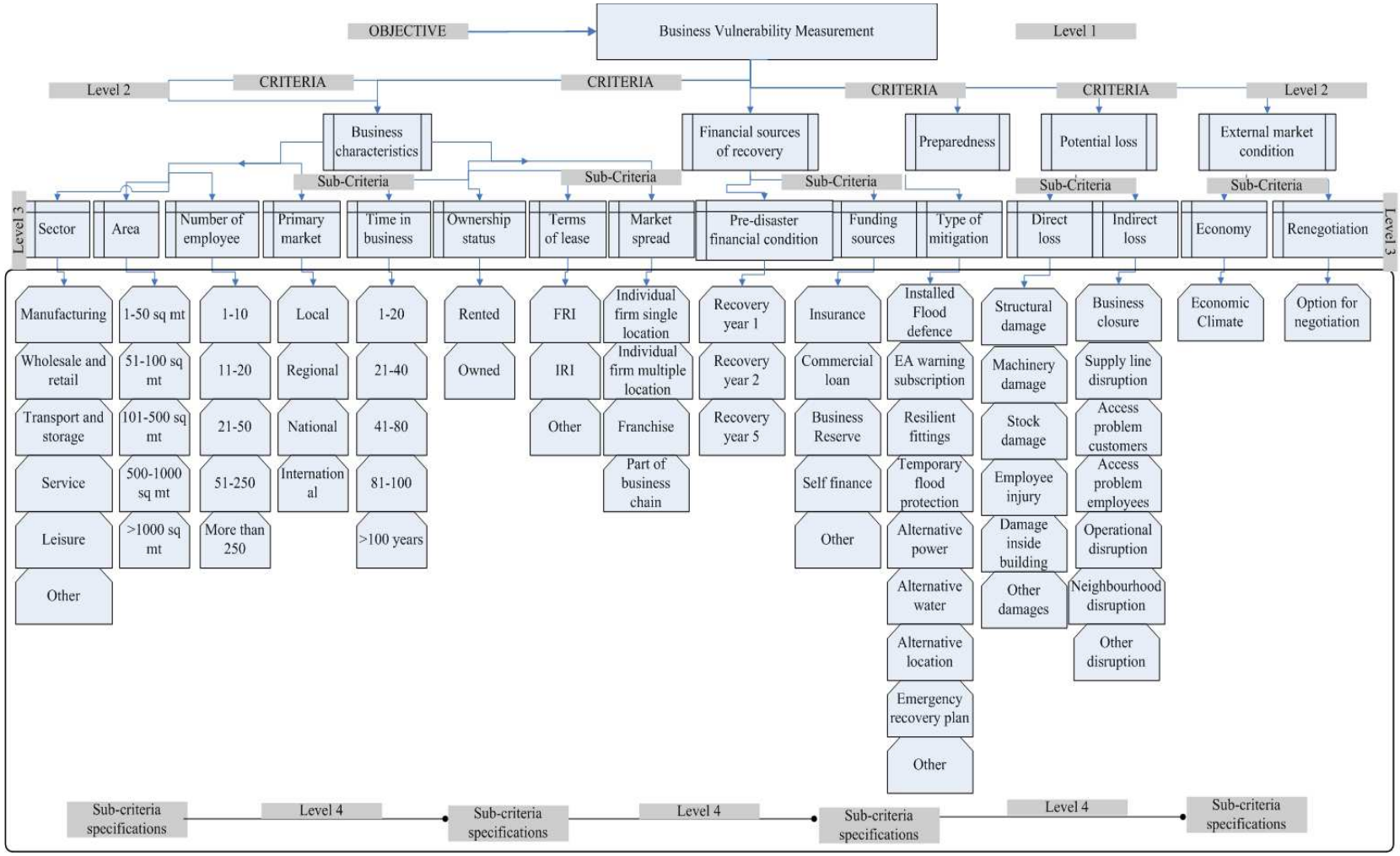


Figure 5.6 Criteria tree for Analysis of Business Vulnerability

The diagram shows four levels of criteria and sub-criteria associated with vulnerability of business for commercial properties. Level 1 indicates the main objective of the model, for example analysis of business vulnerability. The five main influencing variables for business vulnerability are commercial property business characteristics, their financial sources of recovery, level of preparedness, potential loss caused by flooding and market condition are illustrated as the level 2. These criteria are further subdivided into sub-criteria into two finer levels. The characteristics of commercial property business sub-criteria level 4 were obtained from the valuation office dataset. The type of properties was directly taken from the dataset. Size of properties was unequally grouped so that each group will have some data within its range.

The number of employees was distributed based on the Department of Business Innovation and Skills (BIS) definition of small, medium and large businesses. Small organisation are defined by size a limit of employees up to 50, while medium industries have employees up to 250 and larger industries have employees more than 250. Since the number of very small to small businesses was higher in the dataset, the small industries were further divided into smaller units to have a better idea of the distribution of size and impact on them can be observed. The rest of the sub-criteria distributions were mainly based on literature.

After the criteria associated with business vulnerability were distributed for the business vulnerability model, the attitude and perception of people impacts upon vulnerability of value are identified. Since business vulnerability is assumed to have a cascading effect on vulnerability of value, several factors in the business vulnerability model are associated with the three criteria of vulnerability of value: property usability, desirability and marketability. It is the perception of property holders that determines to a large extent whether they are willing to pay or invest in a particular property at differential level of flood risk. Therefore the perception of different sectors was expected to provide a better view of the situation of commercial property value on ground without looking into market data.

The factors required for better understanding of impact of perception on vulnerability of value of property as a response to flood risk are illustrated already in section 5.4.2.7. Depending upon the level of vulnerability of businesses the aim was to see whether the value change based on perception is directly proportional or there are some differences with the business vulnerability and vulnerability of value. The sub-criteria incorporated in property usability criteria (nature and extent of risk, property characteristics and preparedness), were largely associated with business vulnerability. To understand a sector wide perception of vulnerability of value perceptions are sub-divided based on type of property and mapped spatially using GIS techniques. The ranks associated with each sub-criteria factor that is usability, desirability and marketability were summarized to get total vulnerability of value in the selected study areas.

5.7.1 Stage 4: Spatial vulnerability output

The questionnaire responses are expected to return information regarding causes, sources and actions taken to deal with vulnerability situation. Based on the criteria and the ranks associated with the respondents the primary task was to prepare a vulnerability summary table (VST). Since vulnerability is a predictive analysis it was important to understand in-depth condition of businesses. Specific conditions inherent to business properties may predispose them to harm from sudden disruption in business as usual situation which was expected to be obtained from the respondents past experiences of flooding.

5.7.2 Criteria ranking and weights

Over the past few decades researchers have compared and ranked several criteria affecting vulnerability of exposed factors in different disciplines. Often in research the process of combining criteria from different domains such as economy, social, and natural environment to integrate into one is distrusted by decision makers. The main reason is the lack of common denominator among all variables (Janssen, 2001) as well as quality of available data and selection and creation of appropriate indicators to reflect the dynamism of vulnerability. Researchers observed that significance of weights can vary depending on spatial and cultural factors as well as

local policy and practices (Eakin, 2006). The most challenging problem of this technique is assigning weights to the criteria involved which are credible and justifiable (Yeh *et al.*, 1999).

Weights help in determining the importance of one criterion (or sub criterion) over others. In the context of this study, importance could be based on characteristics of property, risk situation or the perception of property occupiers towards risk. It is also emphasized in literature that assignment of weights should be the reflection of public perception or experience rather than the views of a few experts' (Raaijmakers, Krywkow & van der Veen, 2008). Researchers in the field of climate change and disaster management advocates the importance of incorporation of stakeholders input along with expert knowledge to address the inherent uncertainties of socio-economic aspects (O'Brien *et al.*, 2004a; Lorenzoni *et al.*, 2000a, 2000b). The strength of the technique is that, it has the ability to combine information from various scientific fields which is a necessity for studies incorporating human environment interaction.

The ranking value at the sub-criteria level is collected from the combination of analysis of survey questionnaire and insights gained from literature. Weights reflect the relative worth of individual criteria to the total impact on vulnerability. The lowest level of the criteria tree, ranks for sub-criteria which are locally affected (such as business characteristics and type of impact) were assigned based on the responses from flood experienced commercial property occupiers. Other factors such as financial sources of recovery and preparedness pattern were ranked based on insights gained from literature. The result for vulnerability analysis was generated without putting any further weights on the higher sub-criteria levels of hierarchy. It was expected that differential ranking at the lowermost level it will automatically reflect on the higher levels of the hierarchy when the weights will be aggregated by use of the final score.

Research literature in the field of business vulnerability evidenced different effects of some of the sub-criteria; for instance, preparedness against disasters reduce vulnerability (Cutter *et al.*, 2009). Factors such as characteristics of commercial property businesses and type of impact on those properties are very location and time

specific. Therefore ranking of these factors were assigned based on information gained from questionnaire. While factors such as preparedness and status of financial capacity of businesses are well researched in various types of disaster studies, therefore it was decided that those ranks will be assigned deductively from literature. However data will be collected for all aspects of vulnerability to explore the ground condition.

The questionnaire was designed to gather information related to each sub-criterion with reference to cost and time factors. The average value of each sub-criterion was first ranked among themselves to get a higher and lower score. These scores are summed together to get the total rank for a particular criteria. The total score is then standardised based on a scale factor to bring all the factors within the same scale range. The ranking process was used for representing each criterion in spatial dimensions; therefore it was important to have separate spatial ranked layers for individual sub-criteria specifications. Individual ranks were provided for each criteria based on their median value. All the sub-criteria values were then added together to give each criteria layer total score. For example, if the average value for cost of damage and time for recovery (short and long time of recovery) for different sectors were obtained from the collected data, the values are compared and ranked from highest to lowest. This process is repeated for all three factors, cost of damage (in m^2), time of recovery in short term and time of recovery in long term. Highest rank is provided to properties having highest level of damage and took longest time for recovery and vice versa. Finally all the ranks were added to get a total score to identify the relative importance of the sub-criteria variables. The uniqueness of this ranking system lies in its simplicity in identifying the relative importance of the sub-criteria specifications within each criterion.

Based on the understanding of the conceptual model it was revealed that analysis of vulnerability of value needs better integration of social dynamics of risk perception, preparedness and impacts. The psychological issue of vulnerability not only refer to event consequences on an individual but can have a wider impact on the whole real estate market (see section 3.2.3). It was explained in earlier organisational behaviour sections (3.4 and 3.5) how perception can have an impact upon issues of

preparedness and recovery from an event. Therefore to understand perception of commercial property holders towards vulnerability of value, weights were assigned to sector wise average perception of flood plain respondents' direct ranking of vulnerability of value factors. As explained earlier in questionnaire design section, perception data was collected based on statements indicating impact of flood risk on property usability, desirability and marketability. Therefore the ranked variables were the respondents' direct inputs to the vulnerability analysis. Average value of the ranks was considered for ranking properties based on their business vulnerability characteristics. These final ranks were then standardised in a format where comparison is possible with business vulnerability. The following section will explain the process of standardisation.

5.7.2.1 Standardization of scores

As a result of the assignment of sub-criteria scores each specification of sub-criteria now has individual scores within its attribute sets. These values could be aggregated to estimate the total vulnerability score. However, before being able to perform such aggregation it is necessary to perform a standardization procedure to bring all criteria categories of diverse nature, into comparable co-domains. The co-domains used for the purpose of this proposed approach is between the value of 0 and 1 as it is indicated suitable by other similar disaster research (Zabeo *et al.*, 2011; Raaijmakers, Krywkow & van der Veen, 2008). The individual scores of sub-criteria were aggregated to obtain a total score. The total aggregated score obtained for each sub-criterion was then normalized into a dimensionless effect score between 0 and 1. This is a usual choice for the domain of vulnerability assessment (Cutter *et al.*, 2009).

It is evident that normalized data should be aggregated around single numerical output, therefore a non-data driven widely adopted rescaling of multiple criteria from different domains are adopted. The problem with data driven normalization is often associated with problems of outliers therefore an easier way to get around this problem was choosing the non-data driven scale between 0 and 1. The score between 0 and 1 was attributed to each domain value (sub-criteria score) with simple mathematical process of finding scale factor by dividing the largest

standardised value (1) by the maximum scored value (for example 8). This scale factor is then multiplied to each aggregated score to map it to the optimum standardized scale. Therefore each layer is reclassified to match the other layers and have a standardised value (Muller, Reiter & Weiland, 2011). It is easier to convert to standardized value if all the classes or domains have discrete values which were made possible by scoring the values initially by data collected through questionnaire and other literature sources.

5.7.2.2 Integration of GIS

In order to illustrate the outputs spatially GIS is integrated in the analysis. Following various vulnerability research in different fields the most frequent practice of spatial distribution of vulnerability is undertaken by mapping. The different attributes affecting vulnerability, either in terms of sensitivity, exposure and response capacity or in terms of outcomes and impact, are mapped. This study adopted the aspect of mapping by a hierarchic ranking approach of individual property's physical, social, economic and environmental vulnerability factors. GIS is used to undertake the mapping of theoretical determinants of vulnerability in an effort to illustrate spatial distribution of differential capacities and exposures. To interpret the vulnerability and spatial interrelationship between different socio-economic and natural determinants it is essential to highlight the importance of spatial scale as the 'weight and relevance' of dynamic elements of vulnerability assessment changes with changing spatial scale of analysis (Eakin, 2006). It should also be pointed out that there might be abrupt changes in level of vulnerability as a result of changes in scale and data integration rather than smooth transition as it would be realistically thought (O'Brien, Sygna & Haugen, 2004a; O'Brien *et al.*, 2004b). Information obtained from the survey are ranked according to their importance and added as spatial layers. The spatial distribution of vulnerability of value was based on the pre-generated layers from respondents' perception of property usability, desirability and marketability. The total vulnerability of value (Equation 3) towards flooding is based on the formula derived from the conceptual outcome of the conceptual model in section 4.3.

Vulnerability of Value of properties = ∑ Standardized Ranks for Property

(Usability + Desirability + Marketability) Equation 3

5.8 STRATEGY FOR VALIDATION OF RESEARCH

The results from any enquiry based research serves the purpose of bridging the gap between theory and practice. It also acts as a guiding principle to implementation of results to practice. Literature pointed out that validity of research deals with the inferences and statements made in the research and the design that led to the implementation of the study (Brewer, 2000; Winter, 2000). The two distinct forms of validation in research method literature are internal and external validations. Internal validation deals with the research design and analysis including conceptualisation of theory, operationalization of concepts, designing instruments , sample selection, data collection and execution of analysis (Kerlinger & Lee, 2000; Lucko & Rojas, 2010). The discussion in the previous sections indicated that this research had already undergone thorough internal validity by means of comparing research findings with intended objectives of research. The concept of external validation involves generalisation of research findings, that is transferring outcomes of research to another subject population to ascertain certain level of confidence on the findings (Shadish, Cook & Campbell, 2000). The research outcomes can be validated externally by three suggested methods of external validation: replication, boundary search and triangulation.

Replication is the process where the entire research is replicated in another setting and produce same results. This was undertaken by comparing the same process of data collection and analysing them with the identical methods. It is possible to replicate the methods in another setting however it is almost impossible to replicate the results in another setting since no two areas have exactly same situations especially in socially complex research like this (Brinberg & McGrath, 1985).

The other approach was to perform boundary search which is a long process of interaction between replication and triangulation. The method addresses the conditions that the results from the study will not hold true. This aspects are already

included within the definition and scope of study, therefore researchers often prefer not to go again in search of boundaries for the findings of the study (Brinberg & McGrath, 1985).

The other possible approach to validate the findings was to perform triangulation by using multiple data source. Triangulation is a convergence methodological approach which utilises three main domains: the substantive domain (exploration using different respondents or context), methodological domain (exploration using different methodologies) and conceptual domain (with different conceptualisations or models) (Brinberg & McGrath, 1985; Tuuli, 2009). For this research where a number of subjective aspects are involved in the form of perception of one section of population and the outcome from this research cannot be validated empirically through market data, it becomes all the more important to gain knowledge from another section of relevant stakeholders and their perspective towards the issue of concern. Therefore substantive domain of validation was found appropriate for this research.

The data collected from two case study areas will be able to provide the perception of flood plain population and a comparative analysis between the two areas will be possible. However to satisfy the assessment criteria of another perspective, data collection from the commercial real estate experts were decided to be performed. This was undertaken using an email survey and some of the outcomes were compared with the responses of commercial property occupiers. Data collection was mainly based on demographic variables of property experts, their perception of flood risk on the value of commercial real estate market and the factors that according to them have the largest impact on property value in the commercial sector. The compared data will be able to provide a holistic picture of the problem from both demand and supply side of the market. The questionnaire and the information sheet designed for data collection from commercial property experts can be seen in Appendix 5 and 6.

5.8.1 Data collection and analysis for validation of outputs

A web based survey instrument was prepared for property experts based on questions dealing with changes in property value as a result of change in flood risk status. The purpose of the questionnaire was to gain better understanding of external market condition and the potential effect of flooding on the property transaction deals. The survey of property experts' also included questions related to their present experience of dealing in properties at risk of flooding; their opinions regarding the potential vulnerability of commercial properties to differential flood risk and their views on impact of flood resilience on value. The broad theme and factors included in the questionnaire in correspondence with findings from research are shown in the table below (Table 5.10).

Table 5.10 Questionnaire themes for property experts

Themes	**Factors involved**
Demographic variables	Name of company Contact details Type of properties in their portfolio Years of experience
Flood risk perception in property deals	Type of problems faced by agents while dealing in flood affected properties Perception of buyers/ renters about risk of flooding and change in value Solution to the problem of influence of flood risk Negotiation and changes in value of property
Factors affecting property value vulnerability	Risk of flooding Level of defences and preparedness History of flooding Locational impact Mortgage and finance availability Building characteristics

Surveys of businesses and organizations have different nature of challenges from type of survey. Planning such a survey had to be arranged keeping in mind that different business organizations differ in terms of their size, number of divisions, person responsible for administering certain activities, and knowledge about the survey questions. Aspects such as organizational entity, their location, type of business, variation in business size and structure and sample size was taken into account while selecting the experts for the survey. Question formulation and instruction for the survey were investigated and formed in a way easily understandable for the respondents. Considering the rapid development of internet and web services email survey methods are very effective especially when there is requirement of fast cost effective survey to a specific group of professionals.

Stratified sampling was selected as the sampling strategy. Samples were selected from a database obtained from CoStar commercial property agents' online list. Sampling criteria was based on experts having experience of dealing in properties at high and medium risk of flooding. This information was identified by overlaying Environment agency flood zone maps and with the property transaction data points from 1997 to 2013 (data source CoStar property database) to identify experts who dealt in properties in different flood zones. GIS software (ArcGIS 10) was used to identify the sampling frame. Eighty two (82) instances were identified within the property transaction dataset in Wakefield and Sheffield area where experts were involved dealing in properties in flood zone 2 and 3. Out of 82 instances 61 instances were dealt in flood zone 3 and the rest in flood zone 2.

Out of the total number of experts involved in properties at flood zone 3 only 32 agents could be identified in the list with addresses and email id's. The rest were either unrepresented or no address could be gathered from the internet. For the property agents who dealt in flood risk zone 2, 8 agents were identified with their full email addresses as samples. It was observed that often the same agents were dealing in more than one property transaction. The total number of agents in comparison to total number of transactions in higher flood risk zones was much lower in-spite of taking the entire population agents in the transaction dataset as samples. The resultant numbers of agents were not representative enough to identify

perception of economic effect of flooding on properties in different flood zone region. Therefore it was decided to make the sample more geographically representative. This was done by including agents from the north-east region of England from the CoStar dataset for the sampling frame. The questionnaire was kept short with 10 questions to have more chances to get larger response. The cover letter and questionnaire are constructed as one unit however; a copy of the cover letter is also included at the beginning of the questionnaire in case the respondents need to refer to the information again while filling in their response. In the reminder questionnaire which was sent about a week and a half after the main questionnaire included link to the replacement questionnaire for convenience of the respondents.

5.9 CHAPTER SUMMARY

The research design and methodology was discussed in this chapter indicating the implementation of strategy of analysis as the next step of the outline of the research methods. Starting from the analysis needs of this research the chapter has provided a detailed explanation of the rationale and philosophy behind choosing the particular method of hierarchical ranking for vulnerability analysis and representation of the outputs spatially were explained and justified. The adopted research method is quantitative in nature and the chosen base for this is literature and in need to obtain quantitative measure for the analysis. As suggested by the data collection strategy, the target population for questionnaire administration are the flood plain commercial property holders with differential risk status. The following chapter will introduce a detailed exploration of the collected data and interpreting the outcome as the preliminary stage of assessment.

CHAPTER 6. DATA EXPLORATION

6.1 INTRODUCTION

The previous chapter has outlined the research methodology derived from the research needs. The identified variables for investigation of gaps in knowledge related to business vulnerability and vulnerability of value of commercial properties as a result of flooding was commenced. Based on the research design data was collected and reviewed. This chapter will focus on the exploration of the data collected via questionnaire survey. Using the strategies outlined for quantitative data exploration in section 5.6 the analysis of collected data is undertaken for the two case study areas separately first and then an overview of the observed patterns incorporating the two datasets is presented. The aim of this exploration chapter is twofold: firstly, to categorise the observed patterns of loss and preparedness among the total number of flood affected respondents in all the flood risk zones taken together and to access differences of opinion among respondents to evaluate their perception of vulnerability for the next stage of analysis from two different case study areas. This chapter also serves as a background for the forthcoming vulnerability analysis chapter to assess whether the data used for the validation of operational framework are reliable and valid for the analysis.

The result from the analysis of data by using appropriate statistical measures and some exploratory findings included in this chapter will directly address the objective 5 of the research. Under the two themes of business vulnerability and vulnerability of value all six factors (flood risk status, loss due to flooding, preparedness, financial sources of recovery, external market conditions and property characteristics) identified for operationalization of conceptual model are included. The self-administered questionnaire was formulated to gather extensive information from the respondents to gain better understanding of the present vulnerable situation based on their past knowledge and experience.

6.2 STUDY AREA 1: DEMOGRAPHIC PROFILE OF RESPONDENTS IN WAKEFIELD

Total 1830 questionnaires issued, out of which 148 were returned and 102 responses were usable for the analysis. The response rate was lower than ideal for survey analysis but they are not unusual for disaster research. A small response rate does not necessarily mean large response bias; neither does a large response always guarantee a representative sample (Lamond, 2008). Given that no incentive is provided to the respondents and the sizeable sample of over 100 responses is distributed among all flood risk zones (low-51%, moderate-12% and significant-37%) may indicate that bias due to non-response is minimal. The questionnaires sent to different flood risk zones were 51% (Flood zone 1), 12% (Flood zone 2) and 37% (Flood zone 3) and the responses returned from different flood zones matches exactly the same percentage of data which indicates that the distribution of sample was good enough to avoid subsequent data bias and responses were well distributed in all different flood risk zones. The following pie charts are showing the distribution of sampled population and responses received from different flood risk zones (Figure 6.1).

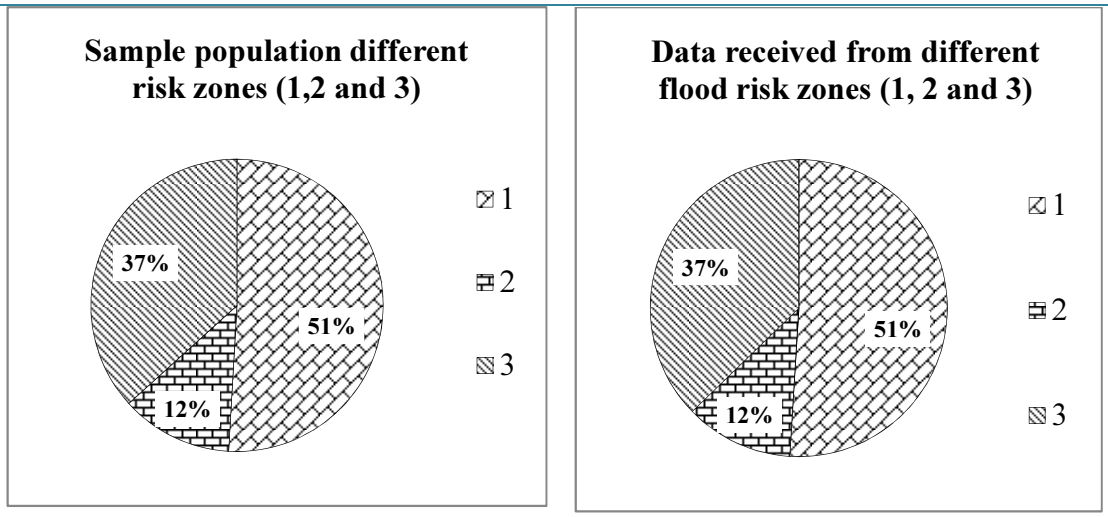


Figure 6.1 Pie diagram showing sample questionnaires send and responses received from different flood risk zones in Wakefield

Respondent's role and experience indicated that while 24% of the total respondents chose to remain anonymous 57% were directors and senior managers of companies, 14% were middle management staff and 6% were operational and other staff. The weighting towards senior managers in the respondents helps in achieving credibility of the research findings. The summary of respondents' years of experience in the field of relevant business shows robustness of their response. The average year of experience in the respective industries is around 16 years. The respondents are distributed among different business types. The highest number of respondents (33%) is involved in service sector followed by wholesale and retail (29%), manufacturing (15%) and other (20%).

Out of total 102 responses from the commercial property occupiers in Wakefield 24% were flood affected and 76% were not affected by direct impact of flooding. Among those who were flooded 42% indicated that they were flooded only once, 33% were flooded twice, 17% flooded three times and 8% were flooded more than thrice in 15 years (1997-2013). The main source of flooding in the area indicated by respondents was rain (35%) followed by mixed sources (33%), overflowing drains and roads (15%), river (12%) and other sources (5%). About 46% of the total respondents suffered from single source of flooding while the rest were affected by two or more flood sources (27% each). This draws attention to the fact

that multiple sources of flooding introduces varied hazard source therefore makes preparedness measures particularly difficult to adopt.

Construction period of the properties in Wakefield area were distributed mainly between pre 1920's (23%), 9% of the buildings were built between 1946 and 1979, 18% were built 1980 onwards. The concentration of properties constructed in pre- 1920's era in the sample survey may reflect the city centre location of the survey. Only 50% of the respondents were aware of the construction period of their occupied properties with renters being less likely to be concerned with property age. The terms of occupancy were evenly balanced between rented and owned properties (51% and 49% of respondents). The type of lease in these properties are mostly internal repairing and insurance (59%), some 41% have full repairing and licensing terms. This observation directs towards the fact that more than half of the business properties with rented owners have limited options to make any strategic structural changes to the property to reduce risk of impact of flooding.

Based on the number of employees working in the businesses 62% were very small businesses with employees between 1-10, 17% with 11-20 employees, and 20% of businesses having more than 20 employees. This implies that there is a large concentration of very small to small businesses with few larger ones. As a result of smaller size the relative effects on these businesses are expected to be generally higher since their strength to survive bigger events are much lower than larger businesses. The majority of the business occupiers indicated their primary area of business to be localised. Almost 65% of the total respondents indicated their primary area of business to be local and regional while 28% said they deal in the national market and only 6% have business connections internationally.

6.3 RESPONSE FROM PROPERTY OCCUPIERS: FLOOD IMPACT AND RECOVERY IN WAKEFIELD

The response from the flood affected population indicated that about 29% of the affected population did not incur any direct cost of damage. Their main problem was the inconvenience as a result of indirect disruptions of flooding. The type of

direct and indirect flood damage experienced by the flood affected respondents are summarized in Table 6.1.

Table 6.1 Flood affected respondents explaining damage (by damage types %)

Indirect disruption from flooding	**Percentage of total disruption(indirect)**
Operational Disruption	30%
Access problem for employees	23%
Neighbourhood Disruption	17%
Access problem for customers	15%
Business closure	11%
Disruption in Supply line	4%
Direct disruption from flooding	**Percentage of total damage (direct)**
Damage inside building	28%
Physical damage of machinery and equipment	19%
Physical damage outside of building	19%
Other Damages	13%
Physical damage to stocks	12%
Physical damage to employees	9%

The median of direct cost of damage among those who were affected by flooding was £3000, 17% spent less than £1000, 21% spent more than £5000 and 42% spent in between £1000 to £5000. When direct effect of flooding showed damage caused inside the building (28%) to be the most commonly experienced effect followed by physical damage of machinery (19%) and structural damage of building (19%). The responses from the flood affected respondents showed higher impact of indirect damage which corresponds to the outcomes of a recent study (Ingirige, Proverbs & Wedawatta, 2012). The most frequently experienced aspect was operational disruption which was followed by access problem to employees and disruption in the neighbourhood. By neighbourhood problems they meant problems caused as a result of flood damage and disruption in neighbouring properties due to refurbishment and repair works, obstructions in access can have some impact (17%)

on the business continuity for nearby businesses. The Comparing the results of this study with a recent similar study on SME's (Ingirige, Proverbs & Wedawatta, 2012) showed some contrasting results indicating travel difficulties for customers to be of highest inconvenience while in this study access problem for customers came much lower in order. This is perhaps due to lower percentage of retail properties among the total number of respondents.

When respondents were asked to rank factors that cost them the most during recovery, property clean-up and loss of sales were among the highest ranked items (2.56 and 2.28 on a scale of 1-5 where 1 indicates the lowest cost and 5 the highest) In terms of time taken during recovery, property clean-up was again ranked highest (ranked 2.80 out of 5) other factors. However, these problems were characterized by respondents as short term issues and were resolved soon after the flood event.

The length of business closure was mostly between 1-7 days with one specific exception of 60 day period closure. The average recovery time to get back in businesses in short term was 3 days and in long term was around 14 days with few exceptions. Variability identified from the survey affecting business operations, indicated about 47% of flood affected respondents in Wakefield were slightly affected, 26% reported of serious disruption and 16% indicated business closure for a short time. The comments from the respondents suggest that even after opening the businesses the situation still lingered on to affect their annual average turnover as illustrated in Figure 6.2.

Business occupiers in Wakefield indicated that the effect of flood disruption on their yearly business turnover was mostly between 6-10% (67% of flood affected respondents), 17% of respondents said they were affected marginally (between 1-5%) and the rest (16%) said the disruption had either no or insignificant effect on their yearly turnovers. Some businesses however indicated that they are still feeling the impacts of flooding, but could not quantify the amount.

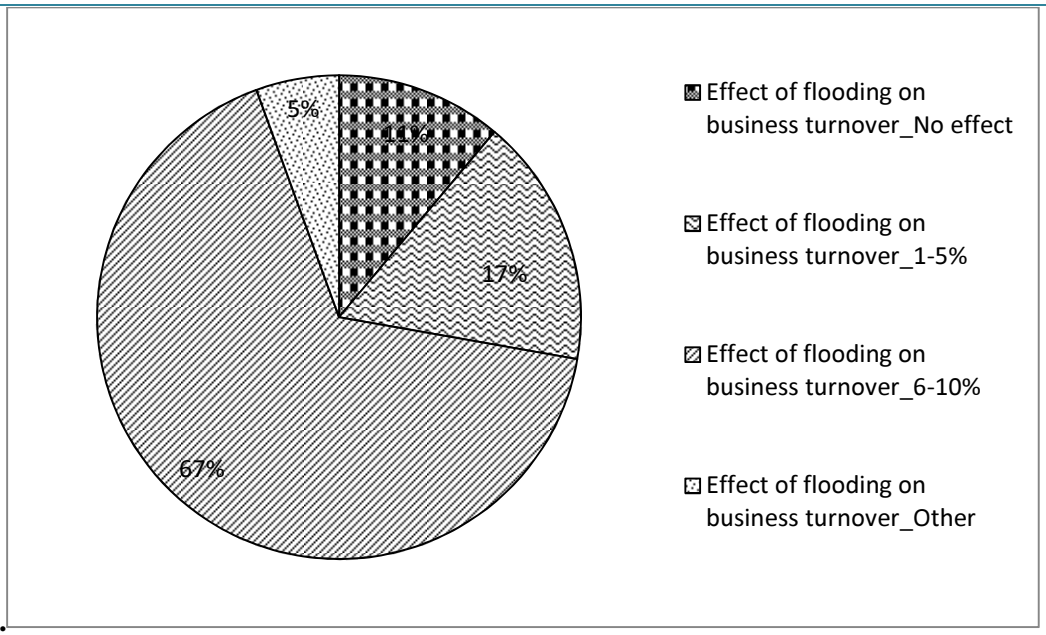


Figure 6.2 Effect of operational disruption on business turnover

It is interesting to notice that besides the 11% of businesses who did not have any impact on their annual turnover, 17% were affected 1-5% and 67% were affected 6-10% of their turnover. Although the businesses were shut down for a short period of time this amount of loss could indicate towards higher impacts of indirect effects of flooding.

Preparedness against flooding showed a general lack of priority among respondents. According to the response from property holders it was observed that 40% of the flood affected respondents did not engage in any activity of preparedness. Out of the remaining 60% of the sample 23% had adopted some preparatory measures before the flood event and 37% considered them after the event. Different types of preventive measures were indicated in the questionnaire and Table 6.2 illustrates the different types of preventive measures adapted by the business property holders in percentage.

Table 6.2 Type of preventive measures adapted by respondents

Type of protective measures adopted	Percentage of total preventive measures adopted by flood plain respondents (%)
Environment Agency Warning	9%
Property Insurance	13%
Business Insurance	4%
Resilient Fittings	6%
Temporary Installation	9%
Permanent Installation	11%
Alternative Location	11%
Alternative power source	4%
Alternative fuel source	4%
Data Backup	9%
Emergency plan	6%
Business Plan	6%
Other Measures	9%

Most businesses preferred using self-finance (54%), some (8%) opted for property insurance, 12% responded that they do not know about the sources of financing and 25% did not respond to the question. 37% of the flood affected samples did not adopt any preventive measures while among the rest 50% adopted between 1 to 3 adaptive measures and only 13% had adopted more than 3 measures out of 13 possible measures included in the questionnaire. Responses on questions of awareness of risk of flooding in their respective properties revealed that mere 18% of the flood affected respondents were fully aware of the risk of flooding in their properties when they first moved in to the property, while 55% had no knowledge and 27% of the total flooded respondents had some primary knowledge regarding their potential flood risk.

Such responses reflects the level of susceptibility of the affected population towards risk of future flooding as well as their non-prioritized attitude towards existing flood risk. The behaviour cannot be attributed wholly to lack of awareness and lack of interest. Researchers have shown that there are lot of other complexities between human thought process and their perceptions towards a particular risk and motivation of taking actions against risk reduction (Dahlhamer & D'Souza, 1997). This can be attributed to factors such as: thinking themselves immune to hazards; not

understanding the actual risk; and overreliance on uncertainty of risk (for details see chapter 3 section 3.4). The next section will provide a similar exploration of data collected from the second case study area of Sheffield to understand if there are any differences in responses as a result of change of geographical location.

6.4 STUDY AREA 2: DEMOGRAPHIC PROFILE OF RESPONDENTS IN SHEFFIELD

The expectation from the second questionnaire survey in Sheffield was to gain as much data as possible from the flood affected population as to compliment the data obtained from Wakefield and also to cross check the validity of data from another source to avoid bias in the analysis and drawing conclusion from one source of data only. As in Wakefield, postal survey responses were generated from different commercial property sectors in all three flood risk zones. The rate of response is similar to Wakefield as out of 1830 questionnaires 152 was returned and 111 responses were usable for the analysis. However, the sizeable sample of over 100 responses is distributed among all three flood risk zones (low-51%, moderate-12% and significant-37%) again indicated that bias due to non-response is minimal because of the even distribution of the respondents from all flood risk zones. The questionnaires sent to different flood risk zones were 84% (Flood zone 1), 13% (Flood zone 2) and 3% (Flood zone 3) and the responses returned from different flood zones 80% (Flood zone 1), 16% (Flood zone 2) and 4% (flood zone 3) match indicates that the bias from lower response rate should not be a problem in this case (see Table 6.3).

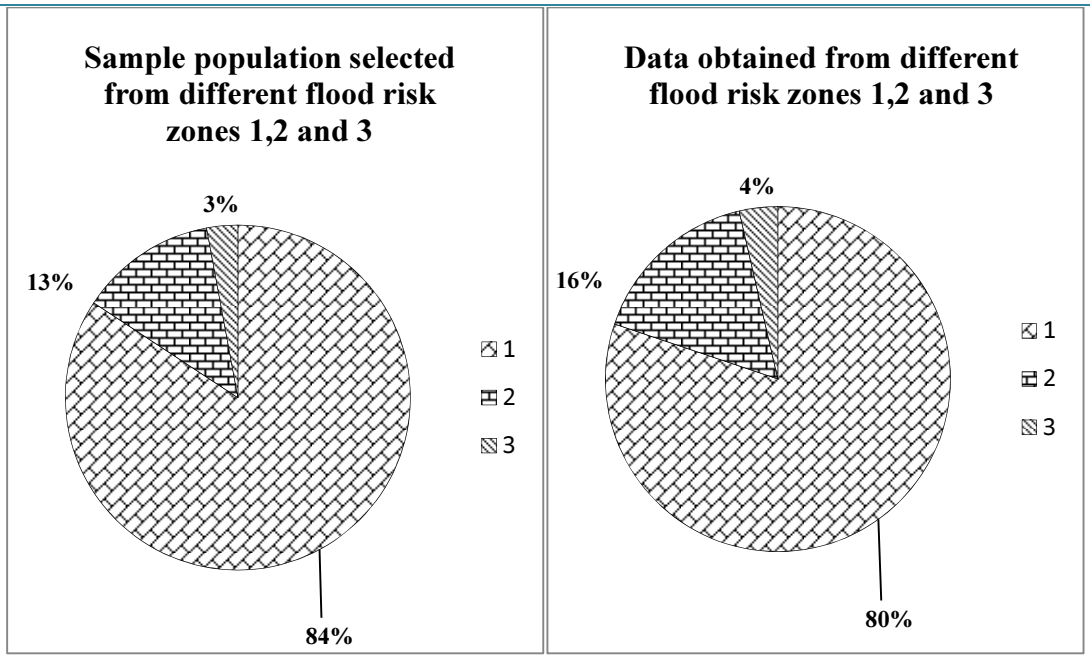


Figure 6.3 Sample questionnaires send and responses received from different flood risk zones (Zone 1, 2 and 3) in Sheffield

In case of type of businesses the highest number of respondents (75%) is from the manufacturing sector, which is not surprising given Sheffield area is more dominant in manufacturing business. This was followed by wholesale and retail (15%), service (5%), and other non-responses (5%) (Figure 6.3). The sector wise distribution of properties is slightly different from Wakefield where the service and retail sectors were more dominant than that of manufacturing. Such differences provided an opportunity to compare the variation in responses in terms of direct and indirect impacts of flooding as well as perceptions of different sectors of respondents for more clarity to the functioning of commercial property system.

Table 6.3 Business type of respondents in Sheffield

Business type	Number of Responses	Percentage of total respondents (%)
Manufacturing	83	75%
Wholesale & Retail	17	15%
Service	5	5%
No Response	6	5%
Total (N)	111	100%

The experience of the business occupiers in their respective field of businesses also provided adequate credibility to the answers similar to Wakefield. Out of total 111 responses 30% of the total respondents chose to remain anonymous 56% were directors and senior managers of companies, 10% were middle management staffs and 5% were operational and other staffs. The summary of respondent's years of experience in the field of relevant business shows that the median value for years of experience in the respective industries is around 12 years (Table 6.4).

Table 6.4 Status of business respondents in Sheffield

Status of Respondents	Number of Responses	Percentage %
Director	42	38%
Senior manager	20	18%
Middle management staff	11	10%
Other	5	5%
Anonymous	33	30%
Total	111	100%

Out of the total number of usable responses 41% of the sample population was affected either directly or indirectly by flooding and 59% were unaffected. Businesses are mainly very small to small (63% and 23%) based on their number of employees (between 1-10 and 11-20) with a small concentration (12%) of medium businesses. Little over half of the sample respondents indicated their primary market to be local (52%), with 21% conducting business on a regional level, 17% having national and only 6% with international connections. According to the responses of business property occupiers about 50% of the property is owner occupied while 45% were rented. Construction period of the properties in Sheffield area were distributed between pre 1920's (54%), 15% of the buildings were built between 1921 and 1979, 15% were built 1980 onwards. 17% of the respondents were had no knowledge of property construction date.

Literature indicated that business with higher occupancy of owners is less vulnerable to effects of flooding than those renting the properties. The reason is that

the owners have higher accessibility to make structural changes in properties than rented property holders. Such changes can help in making the properties more resilient to flooding and thus help in reducing flood impacts. This also depends upon the lease terms of the property holders. One fourth of the respondents have internal repairing and insurance lease while 12% have full repairing terms in their lease documents. Unfortunately, 55% do not have any idea of their terms of lease making them weaker in decision making for risk reduction in the property.

6.5 RESPONSE FROM PROPERTY OCCUPIERS: FLOOD IMPACT AND RECOVERY IN SHEFFIELD

The response from the flood affected sample population in Sheffield again showed the same trend as in Wakefield. The main problem was inconvenience caused by the disruption of flooding indirectly. The type of direct and indirect flood damage in percentage of total damage and disruption indicated by experienced flood affected respondents is summarized in Table 6.5.

Table 6.5 Flood affected respondents explaining damage (by damage types %)

Indirect disruption from flooding	**Percentage of total disruption(indirect)**
Operational Disruption	19%
Access problem for employees	18%
Neighbourhood Disruption	4%
Access problem for customers	22%
Business closure	18%
Disruption in Supply line	13%
Other disruptions	7%
Direct disruption from flooding	**Percentage of total damage (direct)**
Damage inside building	8%
Physical damage of machinery and equipment	17%
Physical damage outside of building	17%
Other Damages	22%
Physical damage to stocks	30%
Physical damage to employees	7%

The median cost of direct damage was about £2000 where 60% of the samples spend less than £5000, 22% spend more than £5000 and 18% did not had to spend anything for recovery purposes. Most significant effect of disruption was caused by access problem leading to operational disruption. In case of direct effect of flooding the effect on stock takes up the bulk of the cost of damages. This is mainly because of the nature of businesses in the area, mostly manufacturing sector where, damage to stock is highly likely if proper measures are not taken to protect before flood event. The same reason corresponds to the majority of damages caused to existing stocks in case of direct damage which shows a general tendency of higher impact compared to Wakefield.

When indicating about factors that cost them highest and took longest during recovery period loss of work was ranked highest followed by customer recovery and structural damage repair for both direct and indirect impacts of flooding. The cost of lost work hour became more significant as against Wakefield mainly because of the nature of industries in Sheffield (more concentration on manufacturing industries) where it is difficult to work remotely. Time distribution did not show much differences of opinion in terms of ranking from Wakefield area and was distributed evenly between almost no time taken to recover and very few days of recovery. Similarly these problems are considered to be short term issues and were resolved soon after the flood event. The length of business closure varied mostly between 2-10 days with few exceptions of longer period of closures up to 30-60 days.

Financial sources used by the majority for recovery actions was self-finance (69%), followed by insurance (24%). Very few businesses have used business reserve (9%) as a means of recovery. The responses from the survey also identified the variable effects of floods on business operations: 40% of total flood affected respondents reported their business was slightly affected, 20% reported serious disruption, 13% indicated business closure and 16% indicated no effect on business. The effect on business turnover can be observed in Table 6.6.

Table 6.6 Effect of flooding on business turnover

Effect of flood on Annual Business Turnover	Percentage of total effect on business turnover %
No effect	47%
Between 1-5%	18%
Between 6-10%	9%
Between 11-20%	4%
Don't know	13%

Preparedness against flooding among Sheffield business occupiers showed a similar lack of prioritization as observed in Wakefield. Based on the survey the business occupiers 34% of the flood affected respondents did not engage in any activity of preparedness. Out of the remaining 66% of the sample 34% had adopted some preparatory measures before or after the event. The rest (32%) did not respond to the question. Out of 13 measures indicated in the questionnaire to choose from 9 measures were chosen by respondents. Table 6.7 illustrates the different types of preventive measures adopted by the business property holders and their percentage in total.

Table 6.7 Type of resilient measures adopted (Percentage % adopting)

Type of protective measures adopted	Type of adopted measures as percentage of total adaptation
Environment Agency warning system	13%
Property insurance	13%
Business interruption Insurance	15%
Resilient Fittings	4%
Temporary flood protection	19%
Arrangement for alternative power	4%
Data backup	7%
Emergency plan	9%
Business Recovery plan	6%
Other measures (not specified)	9%

The number of measures adopted varied among the flood affected respondents. This is clearly observed that almost half of the flood affected businesses adopted no measures at all, while 27% adopted three or less number of measures out of the possible 13 and 24% implemented more than three measures. However most of the measures are adopted on an ad-hoc basis. Therefore adopting higher percentage of measures does not necessarily reflect that those businesses are more protected. The percentage of respondents who did not adopt any measures along with the non-respondents is high (66%) which is an important factor to notice when flood resilience of the area is to be considered.

Responses on questions of awareness of risk of flooding in their respective properties revealed relatively low awareness with only 13% of the flood affected respondents were fully aware of the risk of flooding in their properties when they first moved in to the property, while 40% had some knowledge and 40% had no knowledge about their potential flood risk. The situation is worse than that in Wakefield which can be attributed to the differential attitude towards risk reduction among respondents from Sheffield. The reflection on attitude towards risk reduction measures is found to be generally poorer than Wakefield.

The situation analysis of both study areas highlighted how business property holders look at existing flood risk and what strategies do they adopt to reduce risk of flooding and enhance resilience. It is not possible to generalize the situation to all flood affected commercial properties in the UK, however the discussion above provide a picture of the flood risk situation on ground. The following section will integrate the findings and provide an extensive view of the observed patterns of loss and preparedness among commercial properties based on the knowledge gained from the two study areas. It is acknowledged that situation will vary geographically based on factors which are interlinked with the businesses in different areas; however the aim here is to conceptualize the broader trend rather than area specific empirical analysis.

6.6 OBSERVED PATTERNS OF VULNERABILITY

The questionnaires were systematically structured to gather information about business characteristics; damage caused by flooding, business interruption, mitigation, preparedness as well as the respondents' general perception about changing risk and its impact on value. As discussed in the previous sections certain similarities among the responses from both study areas emerged in terms of their level of vulnerability. The conceptual model identified that loss as a result of direct and indirect effects and preparedness against impacts of flooding are the two crucial criteria in the process of operationalization and understanding vulnerability of an element at risk (see section 4.3 for details).

Business characteristics such as sector, size, occupancy, primary market area, market spread and ownership status are independent of disaster conditions and are inherent within the existing business system. These factors determine to a certain extent why some businesses are more vulnerable than others. Therefore a detailed analysis of both datasets from the two study areas were combined together to gather understanding of the patterns of vulnerability of the business properties. Firstly, the patterns of loss were analyzed by examining a range of impacts followed by the patterns of preparedness among flood affected respondents. The observed patterns in vulnerability of business properties will help in better understanding of inherent processes that affect total vulnerability of business property system and reveal some of the aspects that may affect value in the long term.

6.6.1 Demography of flood affected sample for vulnerability analysis

The sample for analysis of flood affecting business characteristics was based on the data obtained from the properties which were affected by single or multiple sources and frequency of flooding. The flood characteristics for each property were different based on their locational setting such as slope and topography, vicinity to flood source and so on. Table 6.8 demonstrates the characteristics of total flood affected property data that was obtained and investigated for the purpose of analysing criteria affecting vulnerability towards flooding in the selected business properties.

Table 6.8 Characteristics of flood affected sample for vulnerability analysis

Size of Business	
	Percent
1-10 employees	64.1
11-20 employees	17.2
21-50 employees	4.7
51-250 employees	12.5
More than 250 employees	1.6
Total	100.0
Type of Business	
	Percent
No Answer	1.6
Manufacturing	26.6
Wholesale and Retail	20.3
Service	29.7
Leisure and Entertainment	4.7
Other	17.2
Total	100.0
Spread of Business	
	Percent
No Answer	6.3
Individual firm single location	70.3
Individual Firm multiple location	21.9
Part of Business chain	1.6
Total	100.0
	Percent
No Answer	62.5
FRI	1.6
Internal Repairing and Insuring	29.7
Licensing	6.3
Total	100.0
Primary Market	
	Percent
No Answer	1.6
International	4.7
Local	53.1
National	15.6
Regional	25.0
Total	100.0
Spread of Business	
	Percent
No Answer	6.3
Individual firm single location	70.3
Individual Firm multiple location	21.9
Part of Business chain	1.6
Total	100.0

Based on the distribution of data, in some cases there is not enough data, especially for sectors like leisure and entertainment, transport and other mixed businesses, the data was merged together in one bulk referring to 'other', and was aggregated to provide a meaningful analysis. The following section will now elaborate on the different factors affecting patterns of loss and preparedness among business properties.

6.6.2 Observed patterns of loss

All flood affected business occupiers were asked to indicate the type of damage and disruption they suffered during flooding. Of the total (69) flood affected businesses only three indicated that they did not suffer from any direct or indirect damage or disruption. On the other extreme four business occupiers mentioned that they experienced nine out of twelve types of impacts indicated in the questionnaire. On an average, businesses indicated suffering four of the categories of damage and disruption among which indirect disruptions were prevalent. Even for smaller areas the variation of impact is broad where respondents indicated no loss incurred to severe loss and damage.

The cost of damage and revenue loss from no damage to complete disruption ranged between £20 to £7,000,000 among all affected properties. The values include properties with extreme cases with others. The median value for cost of damage was about £2,000 for all properties. The total damage ranged between £200 pounds to £30,000 pounds among properties with employees up to 50 persons. The scale of damage showed signs of increase with size of property. The average damage value was £5,067 and median damage was £2,500. In case of insured properties within the range of 50 employees, the cost of damage ranged between £500 to £30,000. However, the average damage was lower than all other properties (£1,771) and the median damage was higher up to £6,000. It is suspected that those with low value losses would not result in an insurance claim so one would expect to see a bigger range and lower average of actual losses when compared to insurance claims. Table 6.9 summarizes the frequency of responses from different businesses with which they cited each type of direct and indirect impacts on their businesses.

Table 6.9 Direct and indirect effects of flooding

Direct damage	Percentage %	Indirect disruption	Percentage %
Structural damage	17%	Business closure	16%
Machinery damage	17%	Supply line disruption	10%
Stock damage	24%	Access problem customer	20%
Employee injury	8%	Access problem employees	19%
Damage inside building	15%	Operational disruption	22%
Other damage	18%	Neighbourhood disruption	8%
		Other disruption	5%

Direct impact from physical contact with flood water indicated damage to stock (24%) to be most prevalent impact followed by machinery and structural damages (17% each). 18% of business occupiers indicated other damages, but while specifying about other damages in direct damages they implied those associated with indirect damages such as road blocks, un-favourable driving conditions and so on. In case of indirect loss suffered by businesses the most dominant was operational disruption followed by access problem of employees (20%) and customers (19%).

The operational disruption is partly the result of the access problems associated with flooding. Other important loss categories include damage inside building (15%) for direct damage and business closure for short and long term (16%) in case of indirect disruption. When the overall picture of cost of damage and their associated factors indicated by respondents are observed a clear dominance of indirect factors surfaced. At least for these two study areas indirect losses are more prevalent than direct ones. Figure 6.4 shows the hidden loss factors pertaining to impact on business continuity in terms of operational disruption, access problem and business closure.

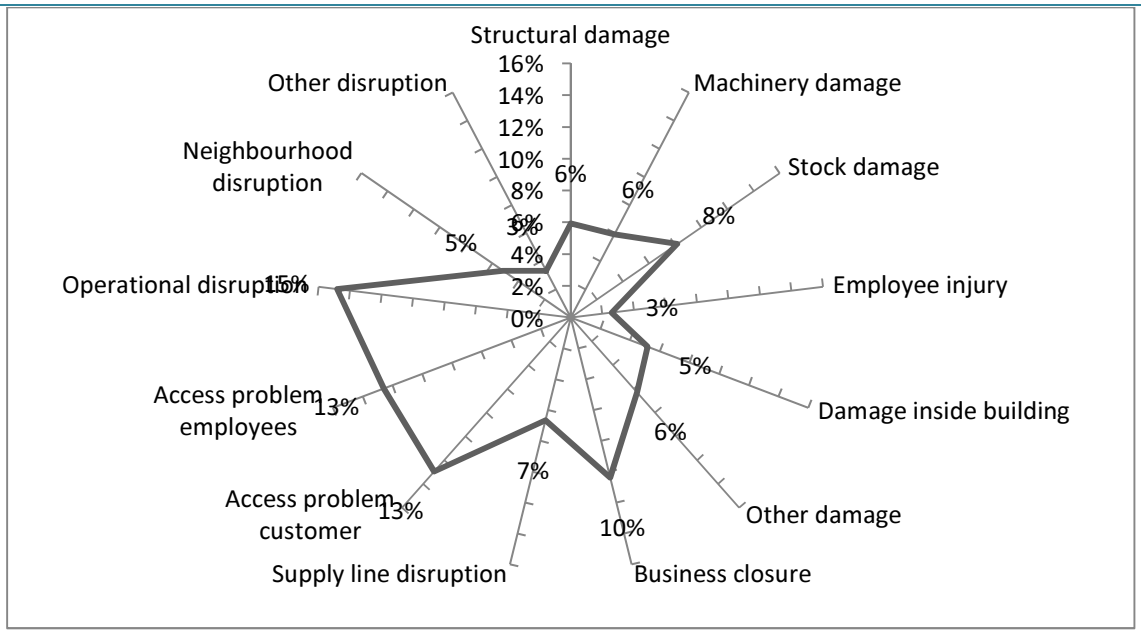


Figure 6.4 Direct and Indirect loss factors affecting business continuity (based on % ranking of respondents)

Documented disaster losses often neglect the other indirect forms of losses associated with the disaster. Among all the responses of flood affected business occupiers only 34% indicated that their business were disrupted by direct damage from flooding and 66% were mainly affected by indirect factors of disruption. From the responses of business occupiers it can be reinforced that the indirect loss factors are more damaging to business continuity in the manner they affect the system.

Respondents were asked to rank between 1 to 5 (1 being no cost incurred and 5 being very expensive) the different factors that affect cost of recovery. Table 6.10 illustrates the percentage of differential cost incurred by respondents based on their differential ranking.

Table 6.10 Differential ranking of importance of factors affecting cost of recovery

Factors affecting cost of recovery	Ranking assigned as % of total cost of recovery	Rank
Sales disruption	13%	1
Clean-up charge	12%	2
Machinery repair	10%	3
Supply disruption	10%	3
Work hour loss	10%	3
Repair inside buildings	9%	4
Structural repair	8%	5
Vacant property charges	7%	6
Data back up	6%	7
Unrecoverable rent	6%	7
Employee compensation	5%	8
Legal charges	5%	8

Disruption of sales was scored highest while employee compensation and legal charges were among the lowest ranked factors. Other factors like clean up charges, machinery and sales disruption, working hour loss and repairing ranked among the next four most costly factors in terms of recovery. Out of 100% of total cost incurred 62% of the total cost was incurred for indirect flood impacts. Therefore, it is evident that the cost incurred on recovering from indirect sources of damage was more dominating.

Answering questions regarding financing sources of recovery the responses were clearly dominated by two sources: self- finance and property insurance. However the difference in their proportions (51% and 19%) clearly emphasize that businesses are still more reliant on self-finance than insuring their properties. This might partly be the result of the general perception of risk among businesses where impact of flooding is considered as temporary. Table 6.11 indicates how businesses responded to questions associated with financing the process of recovery.

Table 6.11 Sources of financing used for recovery

Sources of funding for recovery	Percentage of total sources of financing %
Self- finance	51%
Insurance + Self-finance	10%
Insurance	9%
Business Reserve	3%
Business Reserve + Self-finance	3%
Commercial loan	0%
No preparedness	25%

The observed pattern shows that businesses are still relying mostly on self-finance (51% of total respondents) and not on other available sources of funding. Some businesses (10%) have opted for a certain level of insurance which they complement with self-finance and a very few do the same with business reserve (3%). Besides business reserve, self-finance and insurance the non-prepared or no response accounted for one fourth of the total flood affected sample population. In other words, more than half of the business losses are hidden in the sense that they will not appear in any documentation because of their indirect origin. This suggests that extent of disaster impacts on business communities are much more extensive than standard statistics in many government documents would imply. There were other funding sources indicated in the questionnaire, for instance commercial loan nevertheless none of the respondents indicated that they have opted for this particular measure. This might be either due to lack of knowledge regarding existing funding sources or the businesses do not think that they need to borrow from external sources.

The time taken by the businesses to recover from the effects of flooding was identified by short term recovery and long term recovery. Table 6.12 summarizes the short term and long term impacts on recovery from flooding. Little less than one third (30%) of the businesses indicated no effects at all in the short term; 38% of respondents indicated that they were able to get back to business within 1 to 3 days in the short term followed by 16% took up to 7 days, 7% recovered within 20 days and the rest 8% took longer to recover partially from disruption. In order to get back

to business in the long term, the same set of respondents indicated that 23% of them were able to recover immediately while 30% managed to do so within a week's time, 20% took as long as a month to recover and run their businesses as before and the rest took longer.

Table 6.12 Time taken by businesses to recover

Time for recovery	Short term	Long term
Immediately	30%	23%
Within 3 days	38%	10%
Within a week	16%	20%
Two weeks	7%	13%
Month	3%	7%
More than a month	6%	16%
Year or more	0%	10%

Although respondents said that floods affected their businesses significantly many of them indicated that they were fully recovered within a month or so. Some businesses indicated that they can still feel the effects of flooding and never recovered completely. This was around 10% of the flood affected sample. Although this is a small number of businesses but the fact cannot be ignored that some businesses had far reaching effects of flooding. From such information it is highly likely that the samples are so few in number because those which actually suffered at a higher level and never recovered from the disruption and no longer there to answer the questionnaire and provide information. Therefore it is possible that those businesses which could not recover from the impacts of flooding were not represented in this data. Those businesses might have closed down or moved to another location. This is one of the inevitable drawbacks of retrospective self-administered questionnaires of flood impacts.

It can be noticed that the preparedness actions undertaken by businesses before flood event were mainly concentrated on reducing direct damages, however data indicated that the impact of indirect effect of flooding costs them more to recover. Therefore the insight gained from the empirical analysis suggests that

attention in reducing effects of indirect disruptions and those originates off site are equally important as protecting properties from direct impacts of flooding.

The respondents were asked to rank between 1 to 5 (1 indicating recovered in no time and 5 indicating the longest time taken to recover) the factors affecting time of recovery. Cleaning up of properties (ranked highest in terms of time consumption) and bringing customers back (2nd rank) surfaced as the most time consuming factors that hinders businesses from operating well after disruption. Often the loss of work hour (3rd rank) could be accommodated by working more, but this results in payment of overtime and other inconveniences. For businesses which are affected directly, clean up and drying could take months especially if they do not have resilient fittings installed to protect the property in reducing damage before the occurrence of the event; and therefore further worsens the situation by losing more customers and work hour loss. Other factors such as repair inside building and supply disruption, machinery repair, structural damage and recovery services ranked 4th, 5th and 6th respectively by the respondents. It is possible to reduce such damage and disruption by investing on installation of preparedness and adaptation measures (Gissing, 2003; Kreibich *et al.*, 2007). These responses lead to the next discussion of observed trend of preparedness to see whether changes and nature of preparedness had any effect on the level disruptions.

6.6.3 Observed patterns of preparedness

This is general consensus in literature that better prepared businesses will fare well in case a disaster strikes. The survey enquired about the level of preparedness among flood affected population by asking questions regarding the type of mitigation, preparedness activities and measures they are engaged in and have adopted. A number of actions were provided in the questionnaire with a range of activities to choose from. Enquiry was undertaken also to see whether the preparedness measures were taken before or after any disruptive event. Knowledge gained from the overall scenario indicated that of the 69 flood affected respondents 33 (48%) undertook some sort of preparatory measures and 36 (54%) engaged in no preparatory actions. Such situation can be the outcome of many factors, such as, lack of awareness among flood plain population regarding their risk situation, investment

involved in preparatory and mitigation activities, or priority of other factors over uncertainty of flooding.

Similarly, for type of preparedness measures implemented by the sample population was analyzed, it became clear that majority of the flood affected population preferred easy to procure preparatory measures such as temporary measures rather than adopting permanent solutions for risk reduction in longer period of time (see Figure 6.5). The next group of population adopted insurance as their main preparedness measures; however these are mainly those businesses which are mostly affected by repeated flood impacts. Temporary flood installations were largely adopted in order to keep water out of the property on an ad-hoc basis, which did not help much for higher magnitude of flooding. About 55% of total business occupiers who adopted any kind of preparatory measures adopted only one or two temporary measures, 19% restricted themselves with 3 to 4 measures which involved some temporary and some long term measures and 26% were prepared for flooding with more than 4 different type of measures.

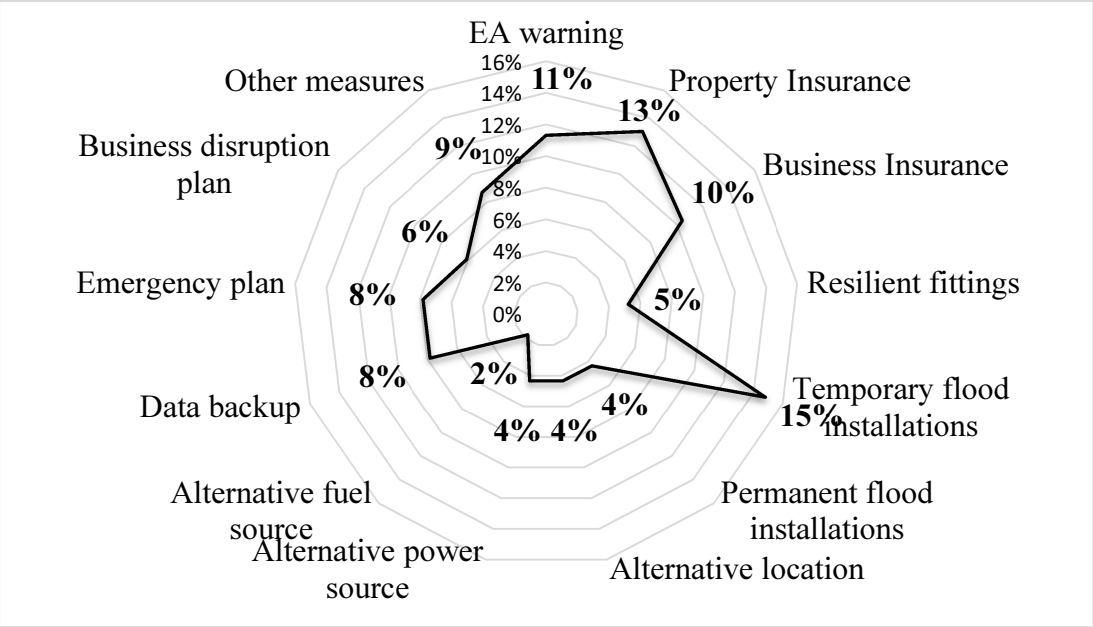


Figure 6.5 Preferred preparedness measures by flood affected respondents

The result suggests a good balance between warning, temporary and permanent measures for flood resilience. Despite that taking preparatory measures

for flood risk reduction is not too common among occupiers there is certain section of population who have started protecting their properties by adopting different available flood protection measures. There is a slight change in attitude towards looking at existing flood risk. To understand the reason further, flood frequency and experience was analyzed among the flood affected population to identify whether experience also has any impact on preparedness for commercial properties as suggested by literature (Flynn, 2007; Rose *et al.*, 2012; Samwinga, Proverbs & Homan, 2004). Flood experience can be seen as having significant impact on the level of adoption of protection measures. An interesting pattern was observed based on the responses from the population who were flooded once and more than once in the study areas Table 6.13.

Table 6.13 Flood experience vs. Preparedness level among all samples

Flood experience	**Percentage prepared**	**Percentage prepared before flood**
Flooded once	39%	26%
Flooded twice	88%	71%
Flooded more than twice	100%	60%
Total	62%	43%

Hundred percent (100%) of the commercial property holders flooded more than twice have taken up some preparatory measures, 88% of those flooded twice have at least one measure, and 39% were prepared after only one event. The average number of measures adopted by businesses did not show much variance based on the level of experience. The range of number of adopted measures varied between 1.6 (flooded once), 2 (flooded twice) and 1.8 (flooded more than twice). When the same analysis was undertaken for only those properties with experience of repeated flooding the result showed slightly improved picture (Table 6.14).

Table 6.14 Flood experience vs. Preparedness level among samples with repeated flood experience

Flood experience	Percentage % Prepared	Percentage % Prepared before flood	Percentage % Un-prepared
Flooded once	44%	24%	56%
Flooded twice	86%	29%	14%
Flooded three times or more	100%	50%	0%

This is slightly different outcome showed a higher level of preparedness among properties with one previous experience of flooding. From these results it can be highlighted that experience plays an important role in taking up preparedness measures and reduction of vulnerability among properties and enhance resilience against future events. From the usual trend seen in the residential sector where it takes more than two or three times for the flood affected population to understand the importance of mitigation (Rose *et al.*, 2012). In commercial sector it seems that those who decide to undertake mitigation activities choose to do so in the light of fewer events.

6.6.4 Observed pattern of impact of external market condition

Information regarding external market condition was associated with open ended questions in the questionnaire where respondents were requested to explain any other conditions that might have affected their level of vulnerability with reference to flooding. External market condition surfaced as the most important criteria which affects vulnerability externally. Here are some of the explanations provided by respondents in light of difficult economic climate and business vulnerability.

The business occupier flooded more than twice but did not close his business and suffered loss of approximately £3000 from one event. He commented that *"it is difficult to assess what changes are due to our problems resulting from rainfall damage and which are due to the prolonged bad economic climate".* He also emphasized by adding that even if business was not being closed at that time the

effects of disruption lasted for years and business had to be closed in 2013. Another businessman who was not affected by flooding directly but access to his business property was hindered indicated that *"years after flooding they are still in recession"*.

A director of engineering consultancy firm referred to the lack of awareness of commercial property holders by commenting that "*people often forget or are generally ignorant of flood issues and go for lowest cost in best market locations*". Another property owner who wasn't flooded informed that *"prime location means maximum income for a retail shop versus cost of flood risk. It isn't usually known how much disruption was caused during flooding as usually a seller would say we were trading within 4 days etc*." Someone commented on effectiveness of resilient measures that *"resilient measures will always be useful selling tool but actuality says only if flooding occurred afterwards and was therefore tested".* One property owner who was concerned of the risk of flooding indicated that he *"cannot get insurance to protect his property after being flooded in 2004".*Therefore it can be noticed that there were mixed responses about economic climate and flooding and their effects on business vulnerability.

When the renegotiation patterns for rental contracts were observed from the responses there was clear indication that there is hardly any effect on renegotiation of property value as a consequence of flooding. Out of 69 flood affected respondents' 29 responded to the question and out of them only 3 have seen some sort of change in rental value and two respondents indicated no change. The rest of the respondents did not go into any kind of negotiation and are also not aware of any previous renegotiation in property value as a result of flooding. Renegotiation of property value due to flood risk is not prevalent in the real estate market. It can be noted that majority of the flood affected respondents still did not realise that with flexible lease terms it is possible to renegotiate rental value in case of disruption and effect on income generated by the property as a result of flooding. Awareness and attitudinal change towards risk is required especially among repeatedly flooded population. Such responses were similar to recent studies on flooding and commercial property investment (Pottinger & Tanton, 2012) where valuers

interviewed had not identified any market evidence on yield or rent adjustments but acknowledgments were made that this is an issue that can be conceivable in the future. Flooding is still considered to be a short term condition which has nothing to do with the market situation This finding justifies clearly that selection of vulnerability approach is more appropriate for this type of research.

Similarly, businesses are more concerned about economic climate than renegotiating their property value as a result of flood risk. Observing the pattern of renegotiation and market reflection on renegotiation of value of business properties direct towards the situation that flood risk has not been considered yet as an important source of disruptive indicator. Flooding can have an effect in the long term and as a result discounts in property rental or sales value are expected to be part of the contractual agreement especially in areas where level of vulnerability is high and increasing. Such outcomes emphasize the importance of perception of property holders towards market value and its vulnerability which can provide a better picture in understanding the predictive nature of the real estate market.

6.7 OBSERVED PATTERN OF PERCEPTION TOWARDS FLOOD RISK AND VULNERABILITY OF VALUE

Insights gained from the literature review suggested that perception of flood affected commercial property sector towards flood risk can have an influence on property value. The questions were intended for all respondents (both flood affected and un-affected samples) from different flood risk zones. Based on the responses of the property occupiers a general understanding of the perception of the business occupiers for the two study areas was derived which later was crucial in generating the vulnerability of value analysis. To understand the level of agreement among respondents, inter-rater analysis for every single item (statements) was performed. Then measures of central tendency were used to understand the data better separately for the study areas. The main purpose of this analysis is to derive confidence in the perception scores for use in vulnerability of value analysis in the next stage of enquiry.

6.7.1 Inter-rater agreement analysis and ranking of perception factors

The inter-rater agreement among the raters for every single item (statements) contributing to property usability, desirability and marketability were calculated. Table 6.15 shows the Inter-rater agreement analysis among flood plain population. The result suggests that there is substantial level of agreements among the respondents. Although the values might look lower than the conventional rule of thumb >0.7 (James, Demaree & Wolf, 1984) this does not mean that these values are not significant. Research suggests that the value for R_{WG} varies considerably as a result of variation in group size (Cohen, Doveh & Eick, 2001; Cohen, Doveh & Nahum-Shani, 2009). Therefore based on the size of the groups (indicated at the bottom of the table) an estimated R_{WG} value for Wakefield and Sheffield were derived.

For Wakefield, based on 10,000 simulation runs, R_{WG} values of 0.11, 0.14 and 0.19 at the 90%, 95% & 99% confidence interval are estimated respectively for group size 102 and 5 response options (that is. 5 point scale). Hence R_{WG} values > 0.19 are evidence of significant agreement at $p < 0.01$. Based on the same rule, the R_{WG} values among responses from Sheffield were also in agreement with each other. In Sheffield single-item inter-rater agreement index, based on a uniform null distribution on 10,000 simulation runs, R_{WG} values of 0.10, 0.13 and 0.18 are the 90%, 95% & 99% confidence interval estimates respectively for group size of 111 and 5 response options (that is. 5 point scale). Hence R_{WG} values > 0.18 are evidence of significant agreement at $p < 0.01$.

Table 6.15 Inter-rater agreement analysis among flood plain population in Wakefield and Sheffield

Index	Description	**$R_{WG\_}$ Wakefield	**RWG_ Sheffield
F1	Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future	0.39	0.55
F2	Loss of income from high flood risk affected properties can negatively affect the demand for such properties in the real estate market	0.31	0.46
F3	Prime location of property is more important factor in determining property marketability than flood risk	0.35	0.4
F4	Easier availability of flood insurance can encourage business owners/ occupiers to opt for insurance against flooding	0.52	0.55
F5	Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market	0.36	0.38
F6	Once a flood disrupted property loses its value in property market it is difficult to get higher value for the property again	0.22	0.45
F7	Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market	0.52	0.59
F8	Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding	0.43	0.61

F9	Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market	0.51	0.67
F10	Properties with history of reduced value as a result of flooding always have low demand in the property market	0.42	0.55
F11	Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future	0.54	0.64
F12	Lowering flood risk by installing resilient measures does not affect property value in the long term	0.53	0.58
F13	More loss of income during flood disruption results in longer recovery time	0.42	0.61
F14	Longer recovery time means higher loss of utility and income from the affected property	0.34	0.49
F15	Suitability for mortgage finance makes a property more attractive in the property market in spite of its high risk of flooding	0.56	0.67
F16	High flood risk and disruption of business encourages property occupiers to move out to a lower flood risk zone	0.47	0.62
**R_{WG} = Single-item inter-rater agreement index. RWG indices are based on a uniform null distribution. Based on 10,000 simulation runs, RWG values of 0.11, 0.14 and 0.19 for Wakefield and 0.10, 0.13 and 0.18 for Sheffield are the 90%, 95% & 99% confidence interval estimates respectively for group size of 102 and 111 for 5 response options (that is. 5 point scale). Hence RWG values > 0.19 and >0.18 are evidence of significant agreement at $p < 0.01$ for the study areas			

A general agreement among the flood plain population can be observed in both study areas with a little higher level of agreement in Sheffield compared to Wakefield. Some of the selected aspects are described below. The factors that gained highest agreement level are suitability for mortgage finance [F15] that makes marketability of property attractive in the property market in spite of its high risk of flooding and investing in mitigation [F11] and preparedness measures [F12, F14] against flooding can have positive effect on demand for the property in future. This implies that population in all risk status zones have a notion of agreement towards their response for the statement on mortgage. Slight variations in the agreement of getting flood insurance [F4, F5] could be observed, as this particular aspect got higher agreement among flood plain respondents from Wakefield than those from Sheffield. The reason might be different patterns of insurance adaptation strategies among business holders in Wakefield and Sheffield. Sections 6.7.2, 6.7.3 and 6.7.4 later provide a detailed evaluation of the different factors affecting value of property and the tendency of the property holders towards those indicators.

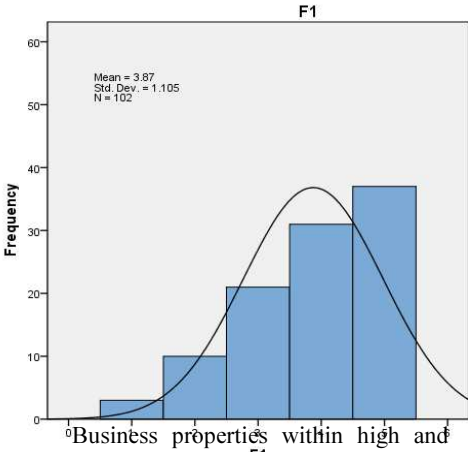
Concerning the terms of lease [F7] which plays an important role in property value, the agreement among the total population of Wakefield and Sheffield varied slightly. The position of agreement about lease aspect was higher in than Sheffield. The responses obtained for desirability to stay [F16] in property as a result of high risk, indicate that respondents in both areas agreed to be neutral about the factor. Sheffield respondents agree a little more than Wakefield. Therefore from the above analysis it becomes clear that the general agreement level among flood plain population is significant. This increases the confidence in the selected data to reflect the actual ground condition in the later stages of vulnerability analysis. The following section will show the tendency and skewness of perception data among respondents from disagreement to full agreement via neutrality by generating histograms.

6.7.2 Wakefield

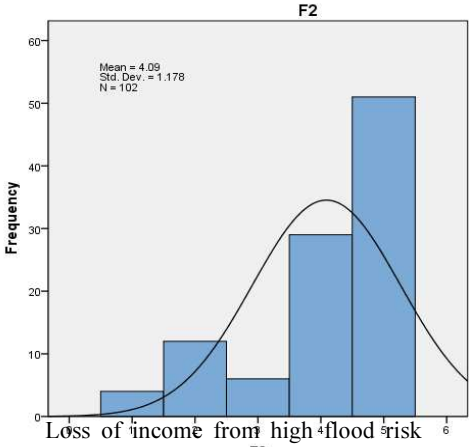
An overall assessment of perception data was undertaken by analyzing measures of central tendency which helped in identifying the spread and distribution

of perception among all respondents. Respondents were asked to rank according to their level of agreement ranging between 1 to 5 (where 1 indicated strong disagreement, 3 neutrality and 5 of very strong agreement). Histograms are drawn to show the distribution of perception of flood plain population for individual statements of perception in Wakefield (refer to Figure 6.6).

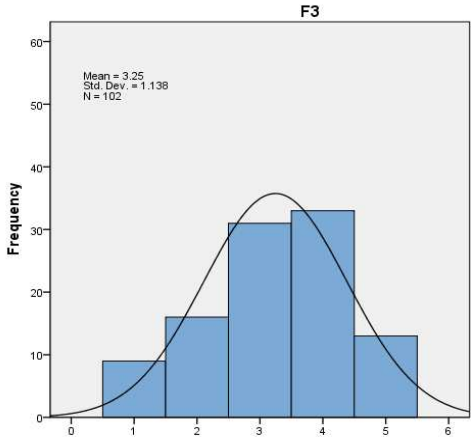
According to the histogram distribution it can be noticed that data of commercial property holder's perception is not normally distributed. The data is generally skewed based on the ranking tendency of people. In cases where the data is more concentrated to the middle, perception is showing greater concentration towards neutral zone. The illustrations help in understanding at a glance the global distribution of perception data in Wakefield. The median range of agreement among all respondents varied between minimum 3 to maximum 4.5 indicating that they were neutral in most issues with stronger level of agreement in some. Loss of income from flood risk was given the maximum agreement by respondents indicating the existing knowledge that flood risk can bring with it significant loss of income and affect business properties to lose value in the long run.



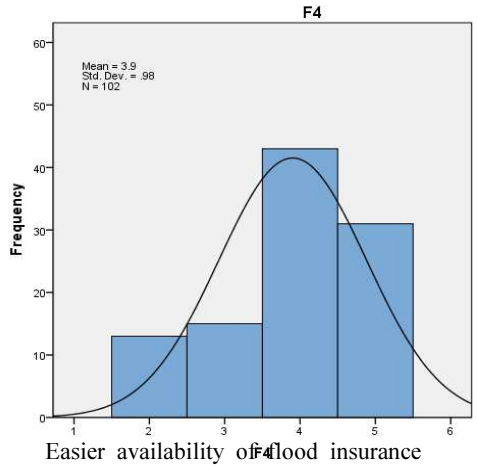
Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future



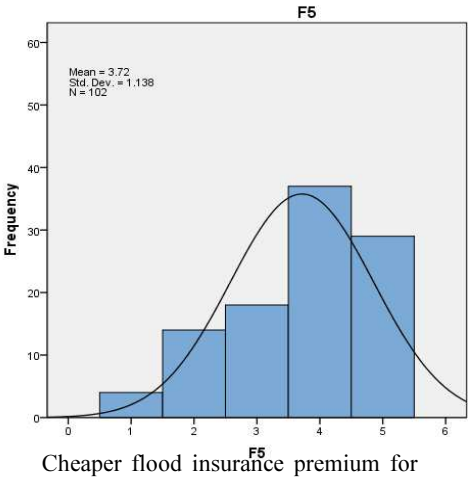
Loss of income from high flood risk affected properties can negatively affect the demand for such properties in the real estate market



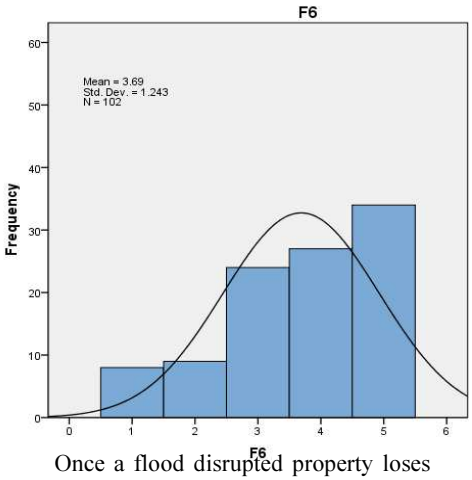
Prime location of property is more important factor in determining property marketability than flood risk



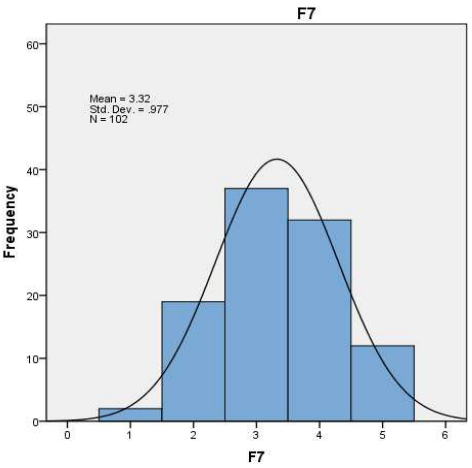
Easier availability of flood insurance can encourage business owners/ occupiers to opt for insurance against flooding



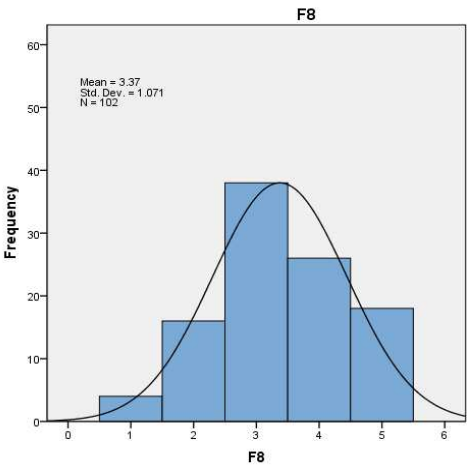
Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market



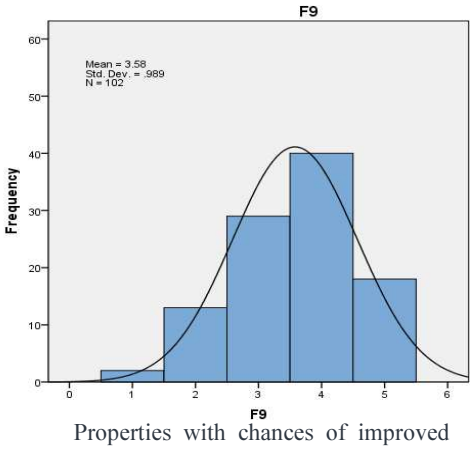
Once a flood disrupted property loses its value in property market it is difficult to get higher value for the property again



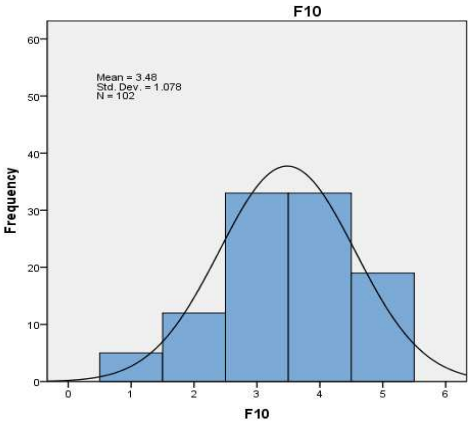
Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market



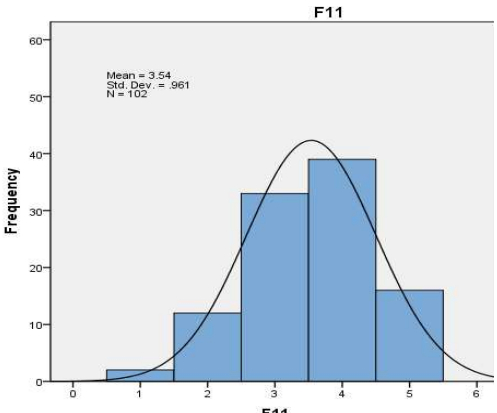
Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding



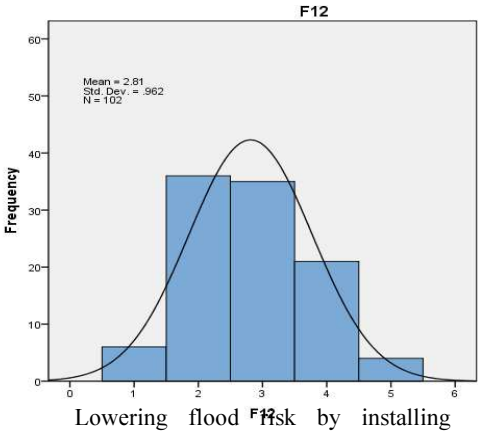
Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market



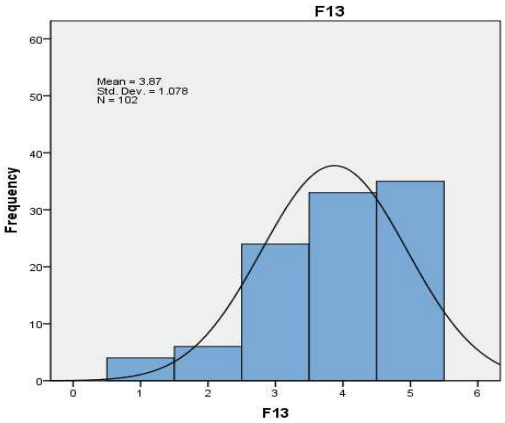
Properties with history of reduced value as a result of flooding always have low demand in the property market



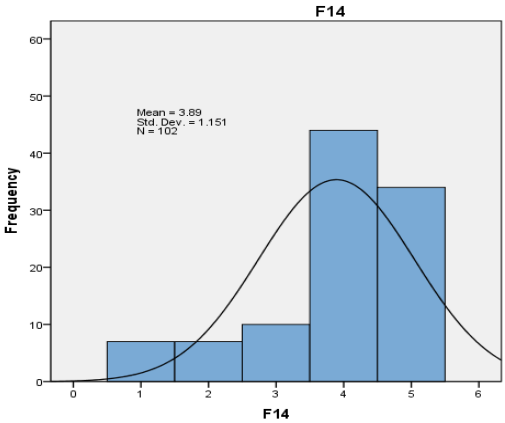
Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future



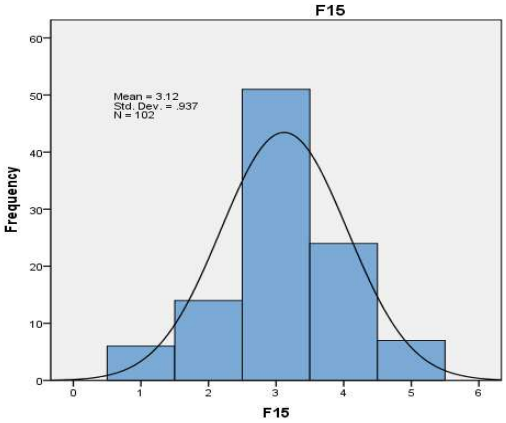
Lowering flood risk by installing resilient measures does not affect property value in the long term



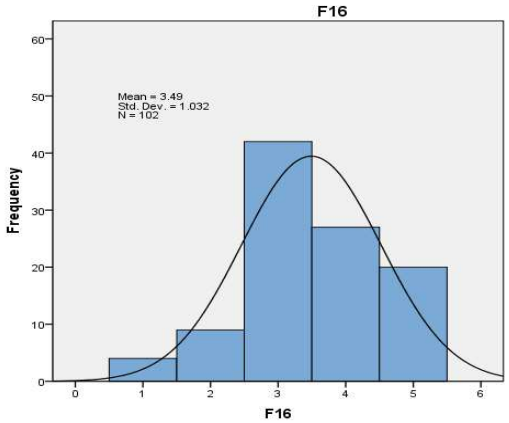
More loss of income during flood disruption results in longer recovery time



Longer recovery time means higher loss of utility and income from the affected property



Suitability for mortgage finance makes a property more attractive in the property market in spite of its high risk of flooding



High flood risk and disruption of business encourages property occupiers to move out to a lower flood risk zone

Figure 6.6 Histograms illustrating perception of flood plain population in Wakefield

It can also be observed that respondents are completely neutral about factors like flexible lease terms, higher expected rate of income generation, and suitability of mortgage finance having impact on property value. Majority of respondents were neutral towards installation of resilient measures and high flood risk and desirability to move out of the business properties as a result of flood risk. This is most likely a reflection of the dis-interest observed among business property occupiers in adopting flood resilient measures. The probable reason behind the property occupiers not wanting to move out of the high flood risk areas may be the closeness to suppliers or

existing customer base, or may be lack of knowledge among occupiers of the risk of flooding. Another aspect in this level of agreement was noticed regarding neutrality of respondents with respect to prime location of properties and their relationship with marketability. Prime location is however, most important for retail properties and among the respondents, only 29% involved retail and whole sale properties, as a result this is highly possible that other property type occupiers did not consider the prime location factor important for the purpose of marketability of the property.

Higher agreements were achieved in factors such as improved resilience will bring more demand for the property and cheaper and easier flood insurance will provide chance to flood plain occupiers to adopt such measures. Investment in mitigation measures may bring up the demand for the property in the market. This implies that on one hand commercial property occupiers are aware that reducing risk of flooding and making properties resilient can have positive impact on the value of property; in contrast, they are not keen on taking up resilient risk reduction measures. It is evident that they have knowledge that more disruption brought by mixed sources of flood can leave them with higher loss of income, and they also agreed that such flood history can affect the value of property in the long run, and reduce the demand for the property.

The survey result shows that respondents are not too concerned about direct physical damage; however it is the loss of income from indirect effects of flooding that they are worried about. The perception of flood risk among commercial property occupiers in Wakefield and their contrasting views on resilience and flood risk with reference to value gives an impression that the understanding of residual risk and how to cope against it is still lacking among the commercial property occupants. Further measures of central tendency of the data are summarized in Table 6.16.

Table 6.16 Statistics for perception of all flood plain respondents in Wakefield

Index	Description (N=102)	Mean	Median	Mode
F1	Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future	3.87	4.0	5
F2	Loss of income from high flood risk affected properties can negatively affect the demand for such properties in the real estate market	4.09	4.5	5
F3	Prime location of property is more important factor in determining property marketability than flood risk	3.25	3.0	4
F4	Easier availability of flood insurance can encourage business owners/occupiers to opt for insurance against flooding	3.9	4.0	4
F5	Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market	3.72	4.0	4
F6	Once a flood disrupted property loses its value in property market it is difficult to get higher value for the property again	3.69	4.0	5
F7	Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market	3.3	3.0	3
F8	Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding	3.37	3.0	3
F9	Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market	3.5	4.0	4
F10	Properties with history of reduced value as a result of flooding always have low demand in the property market	3.48	4.0	3
F11	Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future	3.5	4.0	4
F12	Lowering flood risk by installing resilient measures does not affect property value in the long term	2.8	3.0	2
F13	More loss of income during flood disruption results in longer recovery time	3.87	4.0	5
F14	Longer recovery time means higher loss of utility and income from the affected property	3.89	4.0	4
F15	Suitability for mortgage finance makes a property more attractive in the property market in spite of its high risk of flooding	3.1	3.0	3
F16	High flood risk and disruption of business encourages property occupiers to move out to a lower flood risk zone	3.49	3.0	3

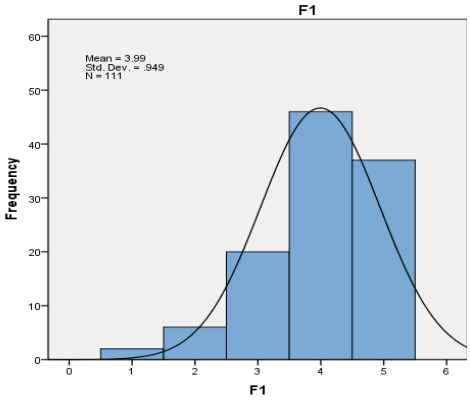
The table provides a detailed view of the understanding of risk perception and their interrelationship with property value of all respondents in Wakefield. As it can be

reflected from the analysis that the factor F2 indicating loss of income having a negative effect on property value has highest level of agreement and F12 indicating lowering flood risk by investing in mitigation factors does not impact value on the long run holds the two extremes of mean value.

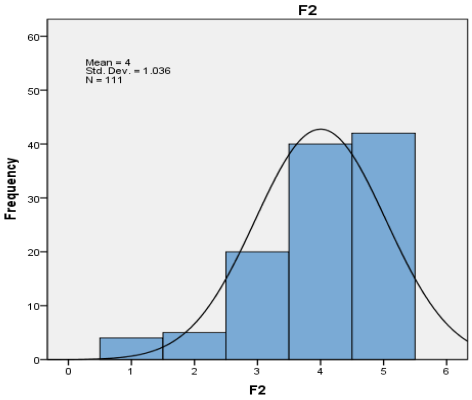
Slight difference can be observed when the perception between flood affected and unaffected property occupiers were compared. Factors like importance of prime location and higher expected rate of income in relation to demand for such properties achieved higher agreement than non-flood affected samples. This outcome is quite expected from flood affected respondents since they have chosen to be at risk in return for certain gains, which evidently in this case comes from higher income generation and prime location.

6.7.3 Sheffield

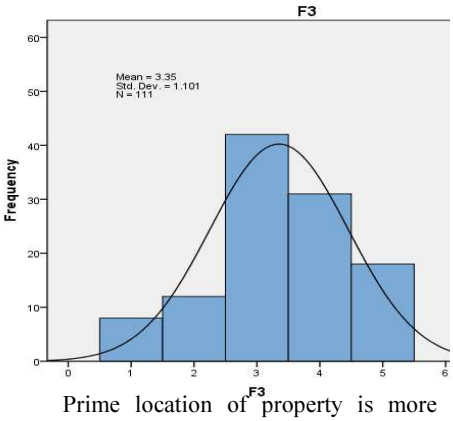
Similar investigation of commercial property holder's perception towards flood risk and its impact on the value of property were undertaken in the second case study area, Sheffield through aggregation of responses from respondents' different flood risk zones. The perception of all commercial property respondents in Sheffield towards risk of flooding and its cascading impact on property value was revealed from their level of agreement to different factors of perception. For individual statements associated with perception factors where respondents were asked to rank according to their level of agreement ranging from 1 to 5 (where 1 indicated strong disagreement, 3 neutral and 5 of very strong agreement) histograms are drawn (refer to Figure 6.7).



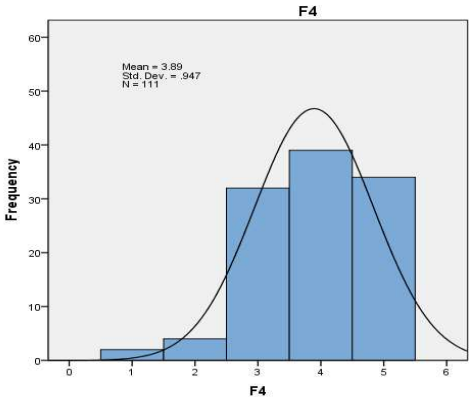
Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future



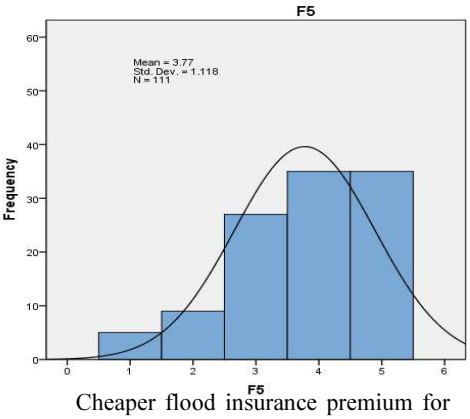
Loss of income from high flood risk affected properties can negatively affect the demand for such properties in the real estate market



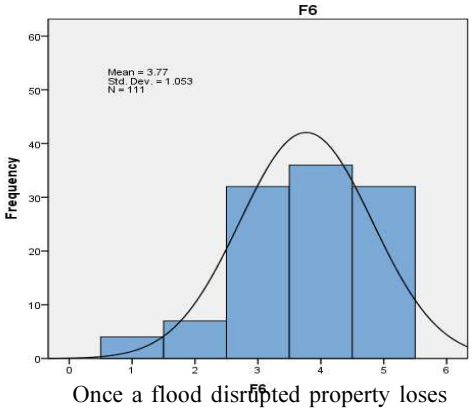
Prime location of property is more important factor in determining property marketability than flood risk



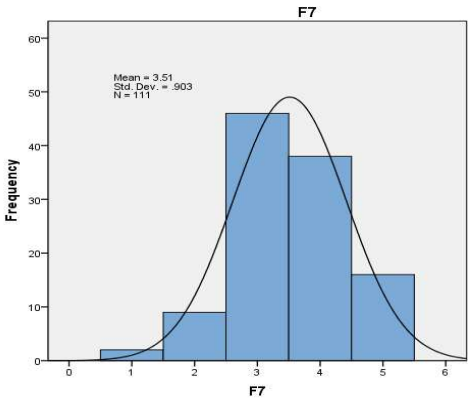
Easier availability of flood insurance can encourage business owners/ occupiers to opt for insurance against flooding



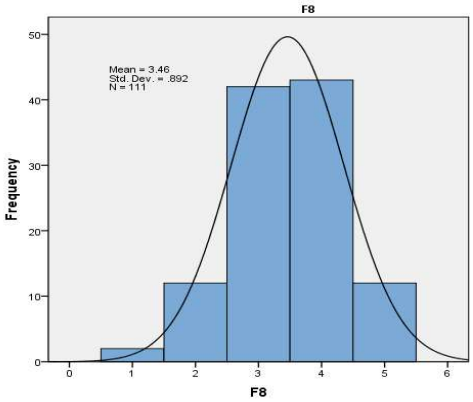
Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market



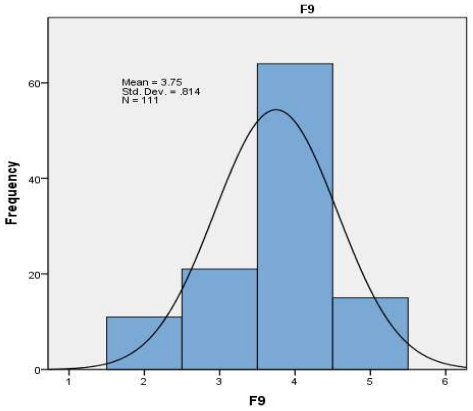
Once a flood disrupted property loses its value in property market it is difficult to get higher value for the property again



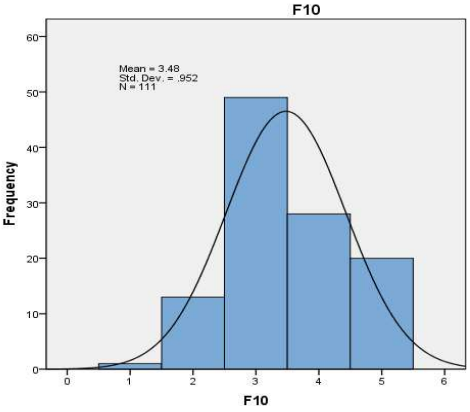
Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market



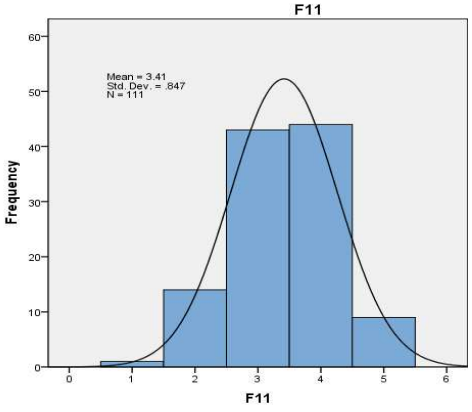
Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding



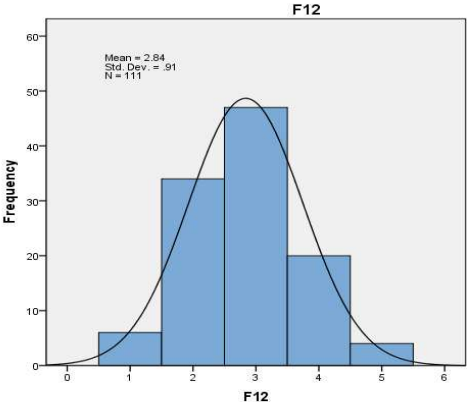
Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market



Properties with history of reduced value as a result of flooding always have low demand in the property market



Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future



Lowering flood risk by installing resilient measures does not affect property value in the long term

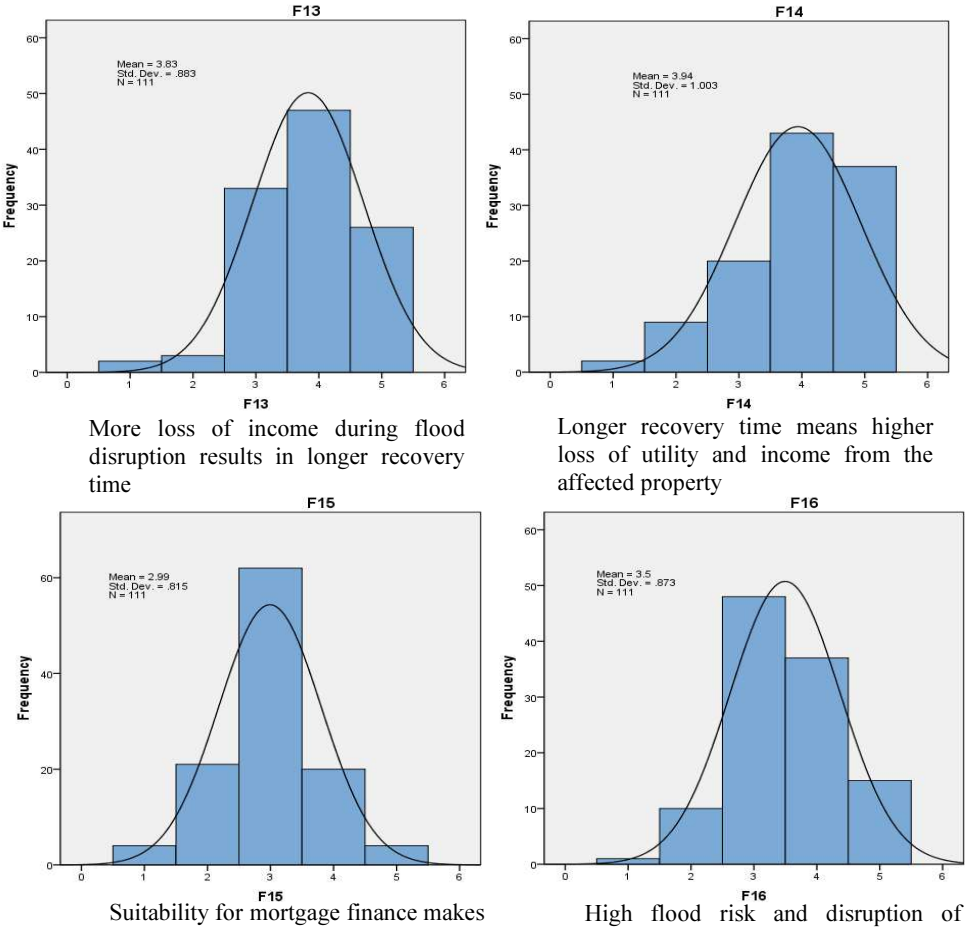


Figure 6.7 Histograms illustrating perception of flood plain population in Sheffield

According to the distribution of data similar tendency of skewness in distribution of perception is noticed in Sheffield. Further statistical analysis of inter-rater agreement was undertaken on the data and is summarized in Table 6.17. The maximum agreement value is reached for factors F2 (Loss of income from high flood risk) and minimum value for F12 (Lowering flood risk by installing resilient measures does not affect property value in the long term) which is exactly the same case for Wakefield. Besides that the median and mode values are similar in most of the cases indicating uniform distribution in agreement of values among respondents in both areas.

Table 6.17 Statistics for ranking perception analysis for all respondents Sheffield

Index	Description (N=102)	Mean	Median	Mode
F1	Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future	3.99	4	4
F2	Loss of income from high flood risk affected properties can negatively affect the demand for such properties in the real estate market	4	4	5
F3	Prime location of property is more important factor in determining property marketability than flood risk	3.35	3	3
F4	Easier availability of flood insurance can encourage business owners/occupiers to opt for insurance against flooding	3.89	4	4
F5	Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market	3.77	4	4
F6	Once a flood disrupted property loses its value in property market it is difficult to get higher value for the property again	3.77	4	4
F7	Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market	3.51	3	3
F8	Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding	3.46	3	4
F9	Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market	3.75	4	4
F10	Properties with history of reduced value as a result of flooding always have low demand in the property market	3.48	3	3
F11	Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future	3.41	3	4
F12	Lowering flood risk by installing resilient measures does not affect property value in the long term	2.84	3	3
F13	More loss of income during flood disruption results in longer recovery time	3.83	4	4
F14	Longer recovery time means higher loss of utility and income from the affected property	3.94	4	4
F15	Suitability for mortgage finance makes a property more attractive in the property market in spite of its high risk of flooding	2.99	3	3
F16	High flood risk and disruption of business encourages property occupiers to move out to a lower flood risk zone	3.5	3	3

It is noted that the perception of all respondents from Wakefield and Sheffield in general did not differ much in their opinion about risk and impact of flooding on value of property. The median agreement ranged between 3 and 4 out of 5, with more than 50% of total respondents indicating stronger agreement in most cases and neutral in others. There was a slight difference of opinion regarding suitability of mortgage terms over flood risk and respondents and the impact of mitigation on property value the overall average agreement between respondents in Wakefield and Sheffield matched well (see Table 6.17). The performance of average agreement among respondents in Wakefield and Sheffield seem to match in general level of details. However, for the specific need of this study it was important to understand whether the flood affected respondents and commercial property holders with no previous flood experience hold a difference in attitude. A similar analysis was undertaken by aggregating data from two study areas and dividing the dataset based on the criteria of flood experience. Table 6.18 indicates a summary of the perception assessment of flood affected and un-affected population in both the study areas.

6.7.4 Perception difference according to flood experience

There are some variation between flood affected and non-flooded respondents perception towards property value. Greater variation in the standard deviation can be observed among non-flooded population than among flood affected population. In mode values the range varies between 3 and 4 among flood affected respondents and between 2 and 5 for non-flooded respondents indicating a larger variation. Figure 6.8 indicates the difference between average perception of respondents and their levels of agreement for factors affecting value of property based on their experience of flooding. The factors where average of flood affected respondents were lower than non-flooded respondents were referring to properties at high risk of flooding and their vulnerability towards higher loss of income and subsequently loss of demand for such properties (F1, F2). The level of agreement among flooded population was highly significant (0.62 and 0.48) indicated by Rwg analysis.

Table 6.18 Statistics for ranking perception analysis among flooded and non-flooded respondents

Ranking factors	Flood affected N=69				Non-Flood affected N=144				Single item Agreement rater Rwg	
	Mean	Median	Mode	Std. Deviation	Mean	Median	Mode	Std. Deviation	**R_{WG}_ Flood Affected	**R_{WG} Non-Flooded
F1	3.86	4	4	0.862	3.97	4	5	1.096	0.62	0.39
F2	3.87	4	4	1.013	4.13	4.5	5	1.14	0.48	0.35
F3	3.46	4	4	1.092	3.22	3	3	1.125	0.4	0.36
F4	3.88	4	4	0.832	3.9	4	4	1.02	0.65	0.48
F5	3.77	4	4	1.017	3.74	4	4	1.177	0.48	0.3
F6	3.7	4	4	1.047	3.74	4	5	1.193	0.45	0.29
F7	3.43	4	4	0.962	3.42	3	3	0.935	0.54	0.56
F8	3.55	4	4	0.883	3.35	3	3	1.021	0.61	0.48
F9	3.81	4	4	0.753	3.6	4	4	0.963	0.72	0.53
F10	3.42	3	3	0.881	3.51	3.5	3	1.071	0.61	0.42
F11	3.43	3	3	0.992	3.49	4	4	0.861	0.51	0.63
F12	3.01	3	3	0.883	2.74	3	2	0.946	0.61	0.55
F13	3.8	4	4	0.815	3.88	4	5	1.05	0.67	0.45
F14	3.81	4	4	0.959	3.97	4	4	1.125	0.54	0.37
F15	3.12	3	3	0.867	3.02	3	3	0.881	0.61	0.52
F16	3.46	3	3	0.884	3.51	3	3	0.982	0.61	0.52

**R_{WG} = Single-item inter-rater agreement index. RWG indices are based on a uniform null distribution. Based on 10,000 simulation runs, R_{WG} values of 0.07, 0.09 and 0.13 and 0.13, 0.16 and 0.23 are the 90%, 95% & 99% confidence interval estimates respectively for group size of 69 (flood affected) and 144 (non-flooded) with 5 response options (that is. 5 point scale). Hence R_{WG} values > 0.13 (for flooded respondents) and R_{WG} values >0.23 (for non-flooded respondents) are evidence of significant agreement at $p < 0.01$

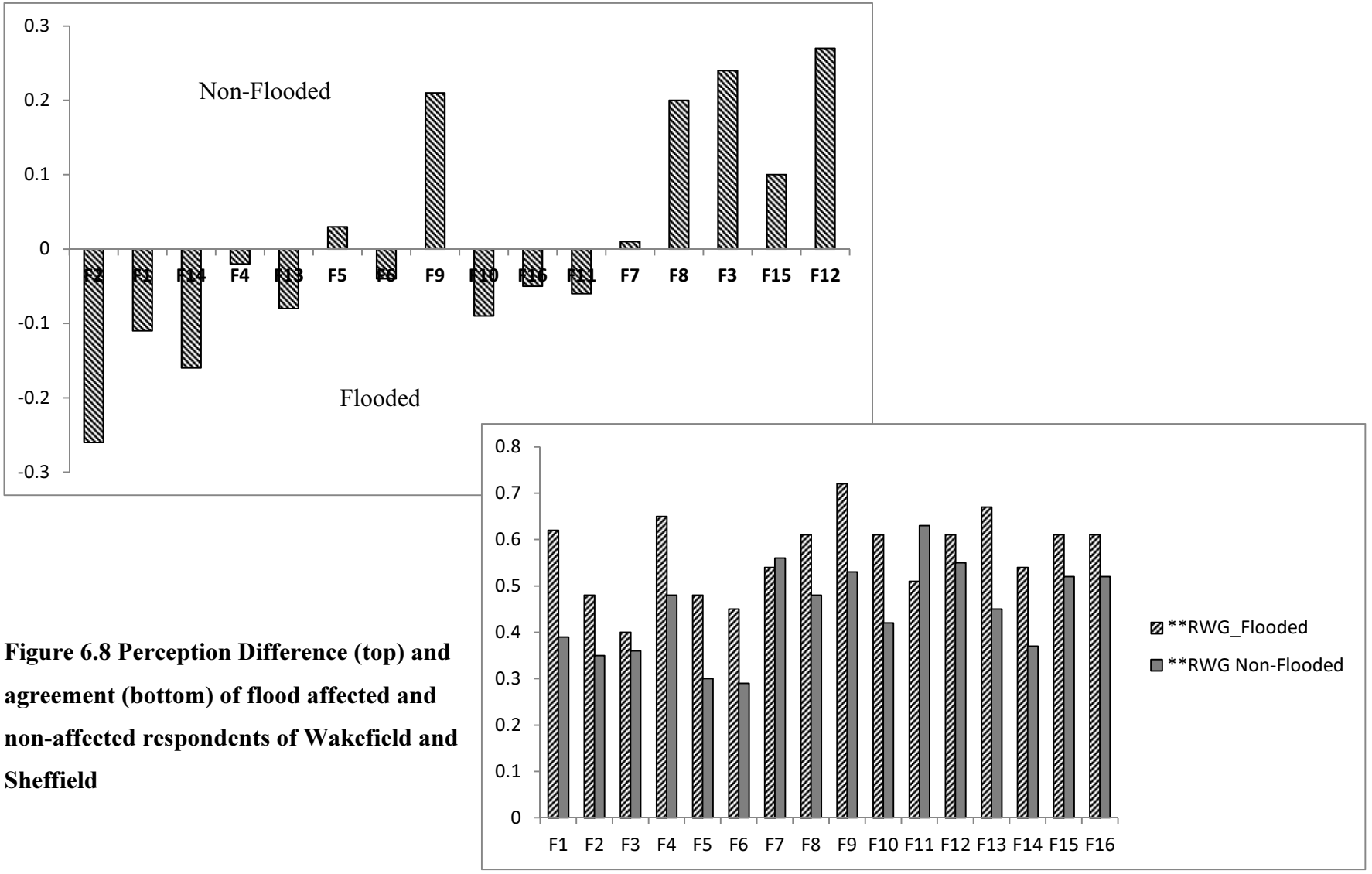


Figure 6.8 Perception Difference (top) and agreement (bottom) of flood affected and non-affected respondents of Wakefield and Sheffield

The agreement among non-flooded respondents was also significant (0.39 and 0.35) but lower than flooded respondents. Factors such as consequence of higher loss of income resulting in longer recovery time and greater loss of utility for properties at high risk of flooding (F13, F14) also showed lower average than non-flooded respondents. The level of agreement among flooded respondents was 0.67 and 0.54 and for non-flooded 0.45 and 0.37, both significant. Furthermore, some variation in average perception can be observed for properties with historical flood experience and its resultant impact on value (F6, F10), flood affected respondents showed lower average than others. The agreement levels among the flood affected respondents (0.45 and 0.61) were higher than the non-flooded respondents (0.29 and 0.42) and both significant. Other factor such as easy availability of insurance will encourage population to opt for them showed slight differences but not as pronounced as the other above mentioned factors.

Alternatively, the main factors where flood affected respondents' average level of perception showed higher value than non-flooded respondents are prime location is more significant in determining property marketability than flood risk (F3), high expected income generation is more important than flood risk (F8), investment in mitigation and preparedness measures can have positive effect on demand of properties at risk but not in the long run (F9 and F12), and suitable mortgage is more attractive factor for determining desirability of property than risk of flooding (F15). The rates of agreement among respondents were significant in all cases for both flood affected and unaffected population.

The differences in perception between flooded and non-flooded respondents clearly show flood experienced respondents are not giving flood risk as their top priority in determining impacts on property value. Instead the reflection is that they understand the importance of investing in mitigation and preparedness activities. But in terms of property value their perception is that such action does not affect value in the long run. Therefore they did not show any intention of moving out of the flood plain and with their businesses in safer locations, and the agreement among them was highly significant. On the contrary, non-flooded respondents were more concerned about high risk of flooding, loss of income and utility resulting in reduced

value. The reason might be that with experience of flooding the respondents were aware of the actual risk and are able to bring in a balance between risk and other commercial advantages of staying in the area. It is possible that those who suffered from flooding do not see it as a major threat and are confident to continue their businesses with the existing level of risk. However it is also possible that with existing market conditions they are yet to realize that with changing risk situation, their properties will be more vulnerable to higher risk of flooding and such changes can have an impact on the value of the property in the real estate market. There are some indications of both factors from the investigation. The evidence for this difference was observed in the pattern of preparedness where experienced population showed higher tendency of taking up preparatory measures than inexperienced flood plain population. Lack of understanding of the situation that commercial property holder's goes through when there is a flood event differs between those actually experienced from those who have no experience of flooding. This does not however mean that the non-flooded respondents are incorrect in expressing their views about flood risk, but it just suggests that there can be a bit of added confusion among the agreement level of property holders which is the result of inexperience.

6.8 CHAPTER SUMMARY

This chapter presented the survey based evidence of property occupiers' experience, views and perception on impacts of flooding, level of risk recovery and impact on vulnerability of property value in Wakefield and Sheffield. It is a descriptive analysis of data collected by use of self-administered postal questionnaire in different flood risk categories. The discussion provided a detailed insight on the perception of commercial property holder's towards risk and value of property. The responses from the survey confirmed from a commercial property sector perspective the growing importance of risk of flooding among property holders. However, risk of flooding is not given top priority in the context of property value change as its impact is not seen directly in the property market transactions. The chapter also aimed to have confidence on the collected risk perception data which will be used for further analysis of vulnerability of value in the next chapter. To build confidence in the data inter-rater agreement analysis was performed. Based on the confidence build

in collected primary data the next chapter will use them to analyse business vulnerability and vulnerability of value for the selected study areas. The analysed data will be spatially represented to illustrate a geographical spread of the vulnerability maps

CHAPTER 7. VULNERABILITY ANALYSIS

7.1 INTRODUCTION

The chapter continues the process of data analysis using the knowledge gathered in the previous data exploration chapter to develop the analysis to the next stage of research. The analysis described here illustrates the spatial distribution of vulnerability of businesses and the vulnerability of value among flood plain commercial property holders in the two selected surveyed areas on a GIS platform. Based on the analysis strategy described in the developmental stage of business vulnerability analysis (section 5.7) this chapter will combine the different aspects that influence vulnerability of business operations and vulnerability of value of the properties associated with those businesses. This is undertaken by scoring the multiple and interacting stressors affecting different type of vulnerability. The result from this combination of empirical evidence illustrates the outcome from the conceptual model in a spatial map.

The aim of the chapter is to reflect upon the conceptual outcome in chapter 5 by incorporating the empirical exploration of chapter 6 to demonstrate the pattern of vulnerability on a geographical scale (see figure 4.5). This chapter indicates potential uses of the conceptual outcome that can be beneficial for determining needs based investment policies. Investment policies can concentrate on mitigation and awareness campaigns on the most vulnerable region. Distribution of vulnerability of value spatially can help in identifying the most vulnerable areas. It is possible to use vulnerability of value information and assist them with appropriate property value discounts wherever applicable. Replicated appropriately, this approach is expected to have significance for relevant stakeholders, allowing them to analyse their present situation spatially; as well as for policy and other decision makers to take appropriate choices in reducing vulnerability.

Some of the insights gained from the questionnaire data collection were further validated with real estate experts who deal in commercial real estate with some experience of flood affected properties. The aim was to gather information

from another perspective. This approach helped in fitting the aspect of data gathering from different sources for the purpose of achieving validation. The chapter aims to fulfil the potentials of conceptual model in the form of vulnerability maps that show the relationship between business vulnerability towards flooding and its subsequent effect on vulnerability of commercial property value (objectives six and seven).

7.2 CRITERIA AFFECTING BUSINESS VULNERABILITY

7.2.1 Ranking of business characteristics

Ranking for business characteristics was grounded on two criteria: cost of damage of exposed factors and time taken to recover from the disruption. The decision to take into account both cost and time factors in ranking were based on the conceptual outcome from the literature review as indicated in conceptual maps (section 4.3.1 in Figure 4.2) Alesch *et.al*., (2001) in the cross-sectional study of 13 natural disasters indicated that scale of property damage is often a less significant factor in the long term than time of recovery. The recovery process is based on business owners' entrepreneurial skills, company's economic health and effect on demand and supply of production as explained earlier in economic vulnerability section (Section 3.3). Recovery factors hold more weight in the model because both short term and long term recovery were included in the ranking process.

When the distribution of data was statistically checked it showed an asymmetrical pattern (skewed normal distribution). Therefore to achieve a more representative average value instead of mean, median was selected as a measure of analysis. In some cases data availability was insufficient to provide ranking for all sub-criteria individually, therefore some of the sub-criteria were clustered together to provide bulk ranking. Table 7.1 indicates the ranking based on the data obtained mainly from responses from the questionnaire.

Table 7.1 Ranking sub-criteria for business characteristics

Criteria	Sub-criteria	Rank (1 = lowest rank)	Data obtained
Sector	Manufacturing	3	Questionnaire response
	Retail and wholesale	2	
	Service	1	
	Leisure and other	2	
Number of employees (size)	1-10	1	Questionnaire response
	11-20	2	
	More than 20	2	
Primary market	Local	1	Questionnaire response
	Regional	2	
	National	3	
	International	2	
Ownership status	Owned	1	Questionnaire response
	Rented	2	
Spread of business	Individual firm single location	1	Questionnaire response
	Individual firm multiple location	2	
Lease terms	Internal repair and insuring	2	Questionnaire response
	Full repair and licensing	1	

The characteristics of businesses are location specific, therefore decision for using ranks obtained directly from collected primary data was made (see discussion on ranking the variables in chapter 5 section 5.7.2 for details). From the derived ranks it can be observed that the manufacturing sector holds the highest rank in terms of their level of business vulnerability when compared to retail, wholesale, service, leisure and all other sectors of businesses in the selected study areas. This result is consistent with the previously reviewed research which showed manufacturing to be the most vulnerable sector (Kreibich *et al.*, 2007). The data indicates that although the total damage for leisure and other services is highest followed by retail and wholesale sector, these sectors were able to recover faster both in short and long term compared to the manufacturing sector. As recovery is considered to be more important for business continuity, faster recovery of other sectors made their businesses less vulnerable than manufacturing sector.

In the case of size of businesses, number of employees is taken as proxy. Results suggest that businesses with a higher number of employees (more than 10

employees) suffered more than those with very small businesses (between 1-10 employees). The total damage (per m^2) for medium sized businesses with number of employees between ten and twenty suffered the most. The businesses having higher number of employees (more than 20) suffered a lower damage/m^2. The time taken for the total recovery for larger business units was longer than that of the small and very small businesses. It is possible that due to the bigger size and several levels of management, it took the comparatively larger organisations longer to decide on their recovery strategy whereas it was easier for smaller businesses to recover easily as they could start on recovery actions immediately.

Similar results were observed for businesses with primary market in various locations (local, regional, national and international markets). Data indicated that businesses with regional market spread were most affected in both short and long term recovery delays. Such delays could be the result of the indirect impact of affected market area within the region. The 2007 flood event, which most of the respondents mentioned was geographically spread over large area in the UK and especially Yorkshire which was badly affected. So this could suggest that this caused delay while the region recovered whereas nationally the impact was comparatively smaller. The businesses were most likely delayed by the indirect impact of flooding in the areas of their primary markets. Those having a market in their immediate locality were able to recover sooner than those dealing with markets in worst flood affected regions in different parts of the country. Perhaps this was because of lack of substitutes – customers came back more quickly to local businesses whereas regional and national customers may have found another supplier. The ranking is assigned accordingly, based on longer recovery periods (both short and long term) for properties having business connections spread at national level followed by those within the region and then the local businesses. The businesses with international connections were slightly delayed by national disruptions but they were also able to recover soon. The longer recovery time made businesses with regional spread suffer from loss of income through supply chain disruption, access problem for employees and goods on time and similar disruptions.

In terms of the spread of businesses in single and multiple locations, the data indicated larger impact on businesses with multiple locations in both direct damage and recovery time. While single location firms were able to recover within one week maximum it took firms with multiple locations much longer to recover (a maximum of 22 days). The differences in terms of short term recovery were also significant ranging from 2 days for single location firms and 5 days for multiple locations. This again shows the influence of indirect impact of floods having larger effect on businesses than direct in situ physical damage. Some of the larger affected businesses were already prepared for direct impact of flooding. However, preparedness against direct impact of flooding could not prevent them from avoiding indirect effects of flooding due to lack of planning for businesses continuity during such situation. Therefore vulnerability of firms having multiple locations shows higher vulnerability weightings than those trading from a single location.

Commercial property is normally leased under three types of leases: internal repair, full repair and insuring (FRI) and licencing. The lease term criteria showed variable effect on ranks based on the terms of lease. Here the differentiation seems to be dominated by direct damages which essentially made the higher affected properties take longer to get back in business. Evidently, recovery time was also partly affected by terms of lease as the property occupiers have less control over the changes they can make for flood risk reduction. Lease holders having internal repair and insuring provides the tenant to be responsible for all the repairs to the internal fabric of the building and the landlord for the external repairs, plant and machinery (for example boilers and lifts). Leases of this kind are usual in multi-tenanted buildings. FRI will normally require tenants to maintain the property in good repair and put it in good repair if it is not at the beginning. Based on the cost of damage and time of recovery it was observed that FRI lease holders normally have the property in good shape due to the repairing obligation of tenants in lease terms. However, in the case of internal repair and insuring, due to the shared responsibility between landlord and tenants, any action from the tenants side which includes structural works might need agreement with other leaseholders or the landlord (RICS, 2012a). Therefore based on the observed data of longer recovery time properties having

internal repair lease were assigned with higher vulnerability ranks than FRI and licensing.

The rented properties generally showed higher levels of business vulnerability than the owned businesses. The recovery times for rented properties are observed to be much longer than owner occupied properties especially in case of long term recovery. The comparison between long term recovery days of owner occupied and rented properties ranged between 2 and 14 days. Such results are similar to other disaster (earthquake) literature (Chang & Falit-Baiamonte, 2002). The rented properties were found to be more vulnerable than owned occupiers and ranked accordingly. The next stage was generation of ranking for the financial sources of recovery which discussed in the next section.

7.2.2 Ranking of financial sources of recovery

Based on the review of literature it is observed that the sub-criteria of sources of finance for recovery are considered to be factors of resilience enhancement. Recent studies indicated that businesses are beginning to realize the importance of business interruption insurance, business continuity planning, property insurance and premise improvement to improve their resilience against flooding (Wedawatta, 2013). Furthermore it was noted that commercial property owners regretted their decisions of not paying excess fee for insurance claim as the damage turned out to be greater in later stages to be repaired by self-finance (Powell & Hardin, 2009). Therefore literature provides good evidence of different type of available financial sources of recovery, organisational behaviour and their effect on business vulnerability and ranking was assigned in a deductive manner.

Literature suggests that businesses with reserve for disaster recovery are often at higher risk of flooding and prone to more damages. They are observed to be flooded more than once and generally possess assets of higher value. Therefore with existing amount of risk, and looking at the overall picture, theoretically these businesses with insurance cover and business reserve are more resilient to flood risk than others (Firth Colley, 2006). Therefore, such properties are assigned a vulnerability lower than properties dependent on completely self-finance for

recovery. Finally, 51% of the properties surveyed were completely self-dependent for disaster recovery with no other sources of finance. This indicates a larger potential for future vulnerability. It is also expected that with changing nature and uncertainty of flood events, any changes in the frequency and magnitude of flooding will have larger effect on those properties with self-funded resources (Dlugolecki, 2008). Thus they are assigned the highest vulnerability rank. Table 7.2 Shows the different ranks assigned to the factors based on the deductive methods.

Table 7.2 Ranking sub-criteria for financial sources of recovery

Criteria	**Sub-criteria**	**Rank (1 = lowest rank)**	**Data obtained**
Funding sources of recovery	Insurance	1	Literature
	Business reserve	2	
	Self-funding	3	

Another factor which represents the economic stability of businesses is the financial situation of the business before and after the disaster occurrence. This was identified by provision of a Likert scale in the financial condition section of the questionnaire. The participants were asked to rank three effective factors: of financial condition of businesses, such as annual turnover, number of customers and number of employees. The recovery time range was for 5 years, divided into one year, two years and five years from the time of disaster occurrence. The factors were then subsequently filtered into two divisions: whether the business situation remained same throughout the range of time divisions got better or became worse than before the occurrence of the disaster event. Ranks analysed by the respondents showed a general tendency towards neutrality. A high proportion of no change in business situation (financial condition of businesses in the last five years (in divisions of 1 year, 2 year and 5 years) was observed among responses and the factor within the sub-criteria were not adding any value to the overall vulnerability analysis. Therefore, the factor of changing financial condition of business factor was excluded from the vulnerability analysis.

To reflect on the empirical data it can be observed that direct damages were higher on average for businesses with insurance and comparatively lower for those depending upon self-finance. This was probably due to the tendency for insurance to be held by those at higher risk and not a causal relationship between insurance and damage. Recovery time in short term ranged between 2-4 days for both insured and uninsured properties. Although the damage in properties with insurance was higher than the uninsured ones, recovery was still made almost at the same time with others. In case of long term recovery, the time taken by commercial properties with insurance was longer. The outcome from the survey is showing similar result as seen in other type of disaster research as well. Such delays in long-term recovery are presumably due to the amount of paperwork in relation to insurance claims and other related works (Powell & Hardin, 2009).

In the study areas about 19% of respondents have some form of insurance followed by 3% who manage their recovery using business reserve for such disruptions. Similar to insured properties the affected properties with business reserve had incurred higher cost of damage, however, as source of recovery funding was already available for them recovery was faster (2.5days in short term). The next section will consider the level of preparedness among the flood affected commercial property holders and their risk status. There will be discussions around how far the preparedness measures helped in reducing the damage level and improved recovery.

7.2.3 Ranking of preparedness

Two sub-criteria of preparedness type, and level of measures adopted are considered for the ranking. Deductive ranking was assigned to the factors. Literature suggested that preparedness reduces vulnerability (Cutter *et al.*, 2008). This is reflected by the outputs from the responses of flood affected properties. The attitude of businesses towards flood risk that often allows them to wait till an event occurs to protect their properties have been explained in literature that the observed nature of behavioural pattern of wait and see attitude of businesses which make them more vulnerable to respond to flood events with higher uncertainty (Dlugolecki, 2008; Crichton, 2006; Yoshida & Deyle, 2005). This factor was reflected in the ranking. Therefore lower vulnerability ranking was assigned to the more resilient businesses,

that is, those prepared before or after flood event are less vulnerable than by those who are not prepared against flooding at all. Literature also suggest that use of hard and soft measures together provides better protection to properties than using only hard measures (Bowker, 2007; Thurston *et al.*, 2008).Therefore higher vulnerability ranking is assigned to properties adopted only hard temporary measures than those adopting both hard and soft measures. Table 7.3 shows the ranking associated with the sub-criterion)

Table 7.3 Ranking for sub-criteria preparedness measures

Criteria	**Sub-criteria**	**Rank (1= lowest rank)**	**Data obtained**
Level of Preparedness	Prepared before and after flooding	1	Literature
	Not prepared	2	Literature
Type of preparedness measures adopted	Only Hard or soft measures	2	Literature
	Both hard and soft measures	1	
	None	3	

While reflecting on the collected empirical data, similar trends can be observed. Out of the total unprepared flood affected properties 69% were in the lowest flood risk zone followed by 19% in moderate risk zone and 12% in the significant flood risk zone. While among the prepared properties, 21% were located in significant risk zone, followed by 14% in moderate and 65% in low risk zone. Therefore it is observed that preparedness among properties at high risk of flooding is more prominent. However, it should be noted that the amount of damage of properties at high risk were able to withstand and get back to business reflects the ability of the prepared businesses to recover faster. When per sq mt of damage is compared between prepared and unprepared commercial properties within significant risk zones, it was observed that damage in unprepared properties (56.19 £/sq mt) was significantly higher than damage in prepared properties (13.67 £/sq mt) indicating that preparedness not only helped in reducing their time of recovery but also reduced level of damage at same level of risk.

In the case of type of measures, businesses adopting only hard temporary resistant measures to protect their properties were affected by larger damage/m^2 (£34.03/m^2) than those adopting both resistant and resilient soft measures (£8.28/m^2). More than two measures does not always reflect effective long term resilient measures rather, as discussed earlier in the observed pattern of preparedness section, more options for preparedness were chosen which were ad-hoc and temporary. Although, the recovery time for properties adopting both measures does not differ significantly (2 to 3 days in short term and 20 to 22 days in long term for hard and both hard and soft measures respectively) the damage rate does.

7.2.4 Ranking of type of impact and flood risk status

In order to rank sub-criteria for flood impact affecting properties, empirical data is used. This is because firstly, the impact of flooding can be locality and property specific and secondly there are not too many reviews on direct and indirect assessment of impacts of flooding on commercial property sector in the UK on which the ranking can be based. Responses from the survey were divided into those affected by direct impact of flooding, indirect impact of flooding and both. Detailed discussion of direct and indirect vulnerabilities has been discussed in section 2.4.4. Median value of effect of direct and indirect flood impacts indicated that indirect impact of flood is higher than direct impact. The average cost of damage for properties directly affected by flooding (£4.57/m^2) were comparatively lower than those affected by only indirect (£4.86/m^2) and direct and indirect impacts both (£9.24/ m^2)

Properties affected by direct damage take comparatively longer than their counterparts in both short and long term recovery. This is because of the amount of cleaning and restoration involved during recovery from direct damage. However when compared to properties affected by both direct and indirect damages the average number of days vary by 2 days between those affected directly by flood water (14 days) and those affected partly by flood water and indirect disruption in business operation (12 days). Properties affected by both direct and indirect impacts of flooding were assigned higher levels of vulnerability ranks followed by properties

directly affected by floods and those indirectly affected (with recovery time ranging between 2 to 7 days for short term).

The ranking for risk status was undertaken based on the official data source of risk categories provided by the Environment Agency. The Environment Agency floods risk zones are delineated based on fluvial flood risk. The flood risk category was identified based on probability of risk of flooding. Details of probability of risk have been discussed in Chapter 2 under flood risk category (section 2.5.1.4). Table 7.4 shows the ranking assigned to the mentioned criteria.

Table 7.4 Ranking sub-criteria for impact sources

Criteria	Sub-Criteria	Rank (1=lowest rank)	Data obtained
Type of impact	Affected by direct impact of flooding	1	Questionnaire response
	Affected by indirect impact of flooding	2	
	Affected by both direct and indirect impacts of flooding	3	
Flood risk status	Low	1	Environment Agency flood hazard maps
	Moderate	2	
	Significant	3	

To reflect upon the collected data, comparison was made among the flood plain population based on the Environment Agency's flood risk designation. Based on the responses of affected population, it was observed that properties at significant risk of flooding had the most damage/m^2 (£24.42) followed by low flood risk areas (£6.73/m^2) and then moderate risk areas (£2.52/m^2). The direct damages are mostly affecting properties located at the significant flood risk zones by fluvial floods. Indirect impacts of flooding can be observed in low risk zone. Properties within the moderate risk zones were observed to be affected by both direct as well as indirect effects of flooding. The effects were not only from direct risk of flooding from river but also other sources such as surface water and ground water floods.

Similar situation can be also observed for recovery time. Properties in significant flood risk zones were able to recover from the stress of the event within a

week's time (experience and comparatively better preparedness can be attributed here). Affected properties in moderate flood risk zone took up-to two months to recover completely in the long term. It is seen from the observed data that factors that are most time consuming for recovery were cleaning and rebuilding of property followed by bringing the customers back and loss of work hours. It is possible that all these factors added to the recovery time of the affected properties. It was especially difficult for those property holders who had no previous experience of flooding and were either not prepared or partially prepared for such events.

7.2.5 Standardization of business vulnerability

The ranks assigned were subsequently standardized based on the strategy explained in section 5.7.2.1 in the research methodology chapter. The following table shows the ranks assigned to the criteria based on commercial property response to the questionnaire and deductive measures. The ranks were standardised between a vulnerability scale of 0 and 1.These standardised ranks were then imported in a spatially representative database using GIS platform and mapped to produce geographical distribution of business vulnerability in Wakefield and Sheffield study areas. The following section will provide a detailed description of spatial business vulnerability in both study areas. The detailed sub-criteria scores and their standardized values based on which the ranks are provided to individual sub-criteria is illustrated in Table 7.5.

Table 7.5 Ranking of sub-criteria scores for spatial distribution of business vulnerability summary table

Criteria	Sub-criteria specifications	Median Cost of Damage (in £/m2)	Median short term recovery (in days)	Median long term recovery (in days)	Rank cost of damage (Higher rank higher value)	Rank short term recovery	Rank long term recovery	Total score	Scale factor (Sf)	Standardized scores
Sector	Manufacturing	5.6	2	14	2	2	4	8	0.12	1.00
	Retail and Whole sale	8.25	1.5	12	3	1	3	7		0.87
	Service	2.13	2	7	1	2	2	5		0.62
	Leisure and other	9.34	2	3	4	2	1	7		0.87
Size	1_10 employees	5.37	2	7	1	1	1	3	0.17	0.50
	11_20 employees	10.22	2	10	3	1	2	6		1.00
	More than 20 employees	7.79	2	17	2	1	3	6		1.00
Primary market	Local	9.13	1	6	3	1	1	3	0.14	0.43
	Regional	5.15	2.5	30	1	2	3	6		0.86
	National	5.6	3	14	2	3	2	7		1.00
Ownership status	Owned	4.57	2	4.5	1	1	1	3	0.2	0.60
	Rented	9.38	2	14	2	1	2	5		1.00
Spread of business	Individual firm single location	6.21	2	7	1	1	1	3	0.17	0.50
	Individual firm multiple	8.31	5	22	2	2	2	6		1.00

	location									
Lease terms	Internal Repair	17.08	7	7	2	2	1	5	0.2	1.00
	Full repair and Insurance and other	7.32	2	14	1	1	2	4		0.80
Funding sources of recovery	Insurance	Ranking based on deductive method						1		0.67
	Business-reserve							2		0.83
	Self-funding							3		1.00
Time of preparedness	Prepared before flooding	Ranking based on deductive method						1		0.50
	Prepared after flooding							1		0.50
	Not prepared							2		1.00
Type of preparedness measures	Only Hard or soft measures	Ranking based on deductive method						2		0.83
	Hard and soft measures							1		0.67
	None							3		1.00
Type of impact	Direct	4.57	3	14	1	3	1	5	0.14	0.71
	Indirect	4.86	2	7	2	1	2	5		0.71
	Both	9.24	2	12	2	2	3	7		1.00
Flood risk status	Low	Based on Environment Agency risk map status						1		0.67
	Moderate							2		0.83
	Significant							3		1.00

7.3 BUSINESS VULNERABILITY IN WAKEFIELD AND SHEFFIELD

The distribution of business vulnerability was generated by overlaying layers of different ranked business vulnerability variables discussed in previous section. The spatial distribution of business vulnerability at post code level in Wakefield and Sheffield are illustrated in Figure 7.1. Based on the distribution of vulnerability it can be observed that there is no particular concentration pattern in and around significant flood risk zones as delineated by the Environment Agency. Business vulnerability of high, medium and low range can be seen distributed along all risk zones in the flood plain area. This can be attributed to indirect impact of flooding and effect of other sources of floods such as surface water or groundwater flooding away from significant fluvial flood risk zones. It is expected that in areas where fluvial flooding is the main concern, businesses with higher vulnerability can be observed in the vicinity of the river.

In Sheffield (see Figure 7.2) a similar tendency could be observed. In the S6 post code area Sheffield where the rivers Don and Loxley meets, there is greater concentration of areas with high level of vulnerability. The observed characteristics found among the respondent's in these areas is that more than one cause of flooding, leading to impacts from direct and indirect sources resulted in higher damage and disruption. This caused businesses to take longer to recover. Many of these businesses were dependent on self-finance which resulted in loss of income and pressure on the business in the long run. The situation further relates to their high dependence on businesses from other areas causing further delays. These areas have often suffered from historical flooding and therefore have higher tendency to fail in case another event of same or higher magnitude happen in future.

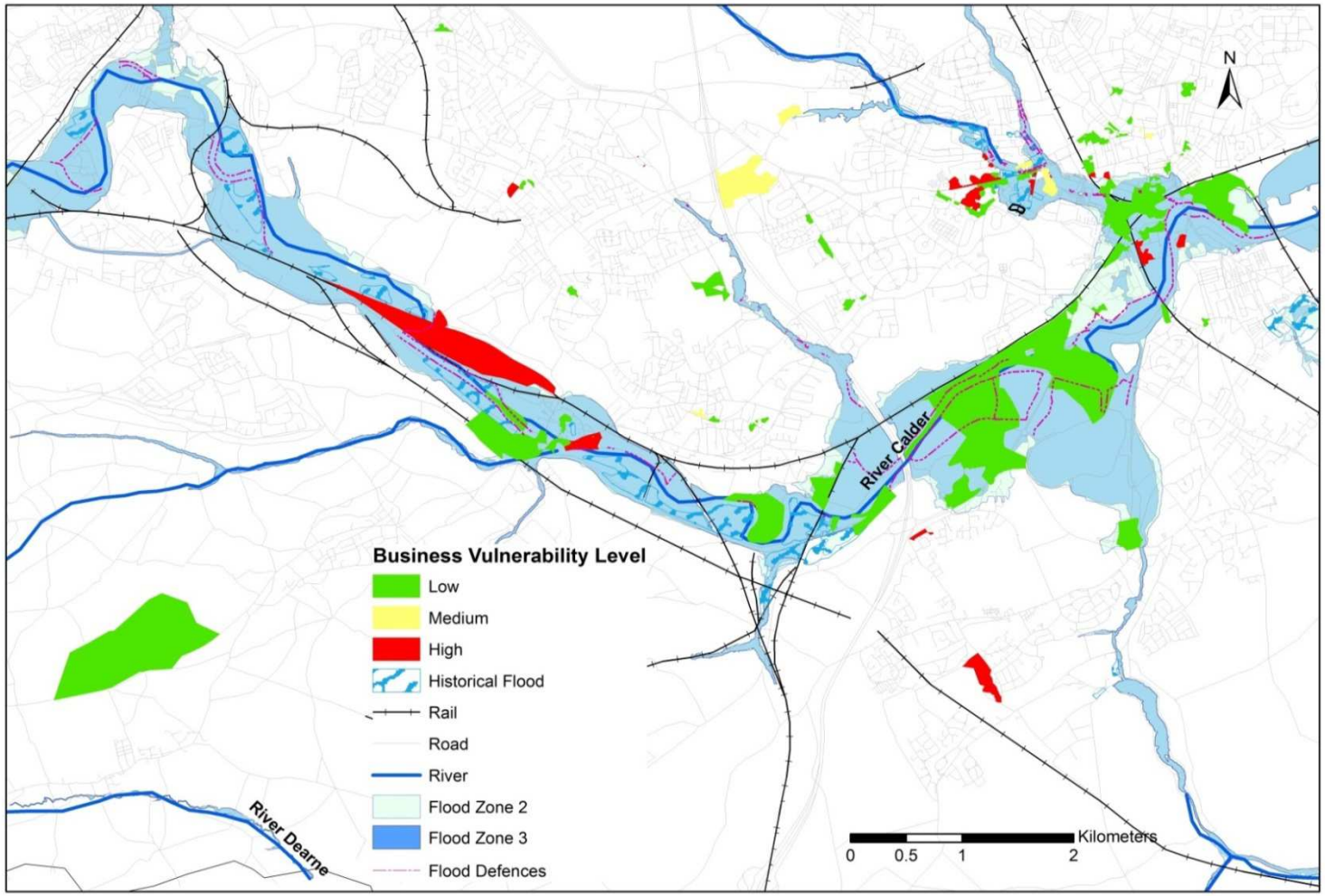


Figure 7.1 Spatial distribution of Business Vulnerability in selected postcode areas in Wakefield

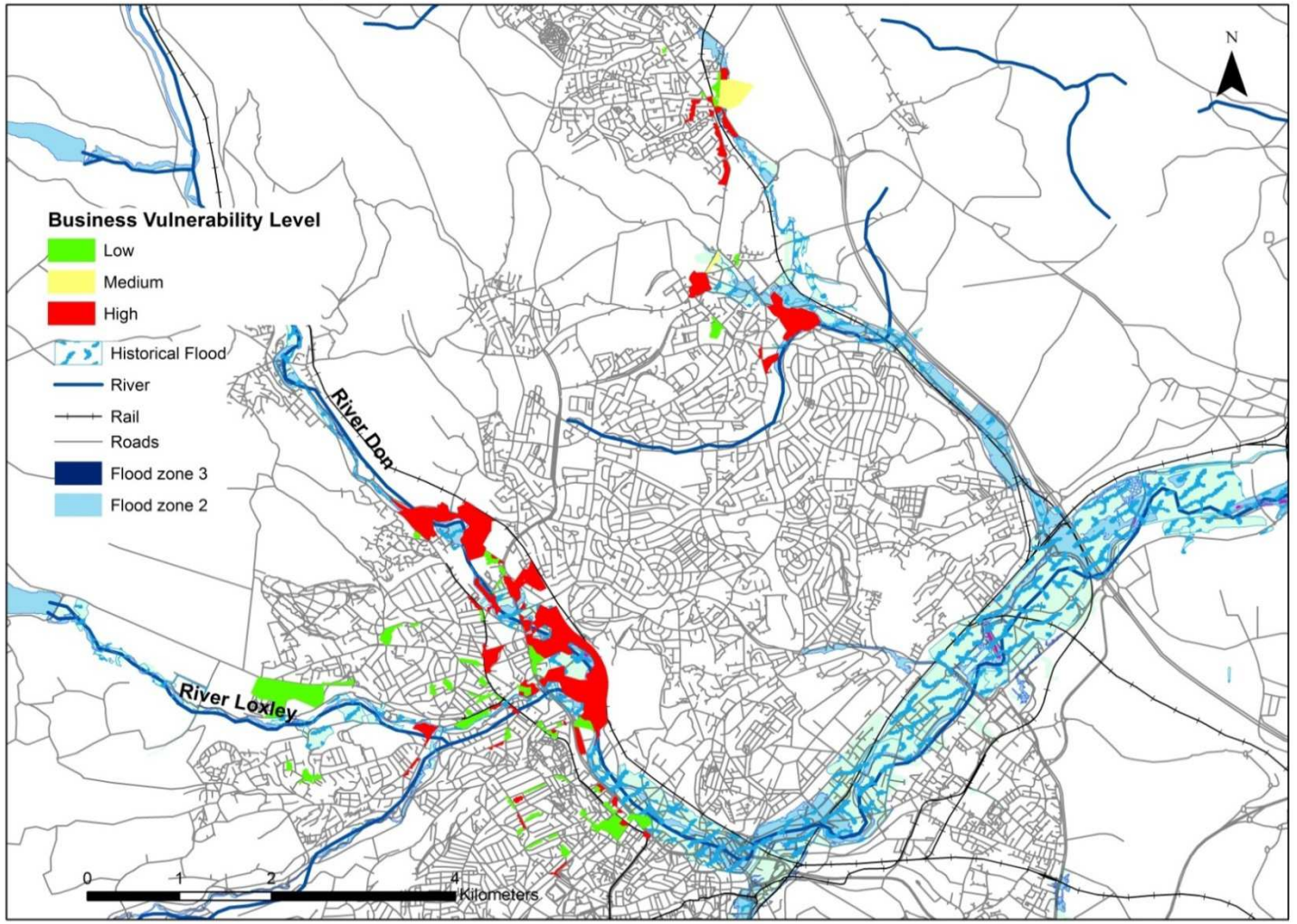


Figure 7.2 Spatial distribution of Business Vulnerability in selected postcodes in Sheffield

The common characteristic features for both areas is that the high vulnerability areas are prone to be affected by both direct and indirect flood impacts leading to high loss of income through damage and disruption. The recovery pattern is often delayed by indirect factors. The patterns have been discussed in details in observed patterns of vulnerability in section 6.6. The short term recovery among such businesses ranged between 3 to 7 days while long term is almost a month. This is understandable that with businesses having disruption for more than a month can lead to larger effect on eventual income generation and overall annual turnover.

Most of the responses coming from these areas showed common characteristics of having no or hardly any insurance, depending mostly on self-finance for recovery. Even with those having some insurance it took them longer to get back in business increasing their chances of reduced income generation for the affected period of time. However the insured businesses were able to get back in business almost at the same time as uninsured low risk businesses. Although, majority of the business properties showed some degree of interest in preparedness, most of them actually adopted preparedness measures after the flood event. Those prepared before the actual event were affected by some damage and disruption mainly from indirect sources. This is because most of these preparedness activities concentrated on defending property from direct damage of flooding in-situ rather than factors offsite. The installed defences proved to be not adequate to protect the entire area because firstly, it is not possible for the defences to protect all properties at risk of flooding and secondly, impact of mixed flood sources in the area could not be protected by flood defences.

The flood affected commercial property holders responded in both areas that they have some knowledge of the flood risk and took few preparedness measures. Although the sources of financing used for recovery was mostly self-finance, a few properties were within the zone of protection from the existing defences which helped them from further disruptions and getting back to their businesses faster in-spite of being in high flood risk areas. Lower levels of business vulnerability could be seen in all three flood risk (significant, moderate and low) zones as well. Those

outside the fluvial flood risk zones (in low risk zone) are either affected by surface water flooding or other interferences like disruption of supply and access as a result of flooding in other areas.

The level of residual risk is prominent in both areas. This can change the level of vulnerability any time from low to high or vice versa depending upon the strategies adopted. With changes in attitude and adaptive strategy among businesses it is possible to change the level of vulnerability. Business vulnerability is a dynamic concept and is closely related to individual businesses and their inherent and external characteristics and practices. The maps here are based on the characteristics of properties whose responses were taken together to generate a general picture and show the level of business vulnerability in specific areas. Since this is a limited sample, those areas showing high vulnerability may change their status when data is populated in the area showing positive change in preparedness and recovery pattern by more properties at risk. The purpose of these illustrative maps are therefore not to help in policy decisions but to show that they have potential to do so and to signal areas where further, more detailed, investigation might be needed. However, the implication of these maps is to demonstrate the strength that spatial representation of business vulnerability can have on the relevant stake holders.

The groundwork for the final stage of analysis of vulnerability of value has been achieved at this stage of business vulnerability assessment. Knowledge of the level of how much businesses are vulnerable to risk of flooding will pave way to understand how vulnerable value can be with reference to business vulnerability. It is necessary to understand whether business vulnerability towards risk of flooding and the vulnerability of value based on market perception of respondents have any inherent similarities and differences among them.

7.4 CRITERIA AFFECTING VULNERABILITY OF VALUE

According to the conceptual model, vulnerability of value towards flooding is based on three factors: property usability, property desirability and property marketability (see Figure 4.5). The data based on commercial property holder's

perception of usability, desirability and marketability of flood affected properties was collected through the questionnaire and ranked. Ranking was based on how respondents perceive the different variables contributing to property usability, desirability and marketability. Perception of respondents at property level were reorganised and averaged based on their types such as manufacturing, wholesale and retail, service and others. Respective layers for each criteria based on their standardized ranks were generated adopting analysis processes (explained in section on data collection and analysis in section 5.6). Table 5.6 in the research methodology chapter also explains the criteria used to weight market perception of vulnerability of value of property and how they have been ranked.

7.4.1 The vulnerability of value model generation

With the standardized ranks obtained for different property types, individual properties were ranked on the basis of their property characteristics, type of preparedness, level of protection and risk status. This implies that the ranks are indicators of how commercial property holders in the market actually perceive the properties with specific characteristics located within certain risk status. The vulnerability of value spatial layers was generated using ARCGIS 10 software. Vulnerability levels were then generalised on a postcode level to show distribution of market perception of vulnerability of property value to flood risk. The final spatial vulnerability maps indicated the distribution of vulnerability of value at selected postcode level in both Wakefield and Sheffield based on the sector wise perception of commercial property holders.

The output from the spatial vulnerability of value analysis can be interpreted as representation of spatial differential on the vulnerability of value of property based on their vulnerability towards potential risk of flooding and risk perception of the occupants of properties within different levels of risk within the flood plain. Appendix 7 shows the ranks of different layers for analysis of vulnerability of value based on respondents' perception of property utility, desirability and marketability. The following section will elaborate geographically the distribution of market perception by different sectors followed by spatial distribution of vulnerability maps

and discuss the common features of vulnerability of value in the two study areas and its comparison with business vulnerability. The distribution provides opportunity to make a comparison between business vulnerability identified through the experience of flood affected respondents and the perception of vulnerability of value of all respondents towards flood affected and unaffected properties at different levels of risk.

7.4.2 Vulnerability of value in Wakefield and Sheffield

The sector specific market perception of all respondents is shown graphically in Figure 7.3. The figure indicates variation in market perception among respondents from different sectors. The manufacturing sector in both study areas shows similar results. Despite the neutral responses, the primary concerns for manufacturing sector's usability of property value are higher flood risk and resultant loss of income. The manufacturing sector respondents are more concerned about the history of flooding in a property and effectively their perception is that such condition may have an impact on future property value. As for property marketability, respondents perceive that with higher loss of income and longer recovery time loss of utility can result in making value vulnerable to changes in the market. The wholesale and retail sectors are also concerned about high flood risk, loss of income and cheaper flood insurance availability to help them in business continuity. The high percentage of neutral views regarding property desirability suggest that whole sale and retail sector are not too concerned about stigma from historical flooding or flexible lease terms or higher investment in mitigation activities, their main concern is reduction in recovery time and continued utilisation of the property on which their businesses are located. They are willing to pay more towards value of property in the market where recovery could be faster.

The service sector also showed similar responses in terms of high flood risk and higher loss of income hampering property utility and therefore value. Furthermore, a high proportion of the respondents from all sectors showed interest in insurance if it is easily available but are not willing to pay adequately. Majority of the respondents agreed towards cheaper insurance for high risk prone properties.

This is also reflected in literature that a large proportion of UK commercial properties are either uninsured or underinsured (AXA, 2009, Pitt, 2008). The perception of stigma from historically flooded property exists in this sector concerning property desirability. Similar to the other two sectors, service sector is also concerned of loss of income and longer recovery times to be factors that can affect property marketability in the real estate market.

The rest of the commercial properties showed perception towards high and medium risk properties to be more vulnerable in terms of their usability. The perception of respondents from all four sectors matched regarding the lack of demand for historically flood affected properties. The service and manufacturing sector respondents even emphasized that once a property reduces its value as a result of flooding it can never regain its lost value. Even if such effects are not visible in the market as when respondents were asked to indicate any negotiations of property value as a result of flooding there were hardly any indication of such. This implies that in peoples mind flood affected properties are a risky investment, but in actual market this does not seem to be reflected by the transactions taking place.

Finally loss of income and longer recovery time seem to have high impact on vulnerability of property and the perception of respondents show that they are aware of it. The general perception among manufacturing and other sector respondents indicate that the loss of income and longer recovery times are their immediate concern which can make value of property vulnerable.

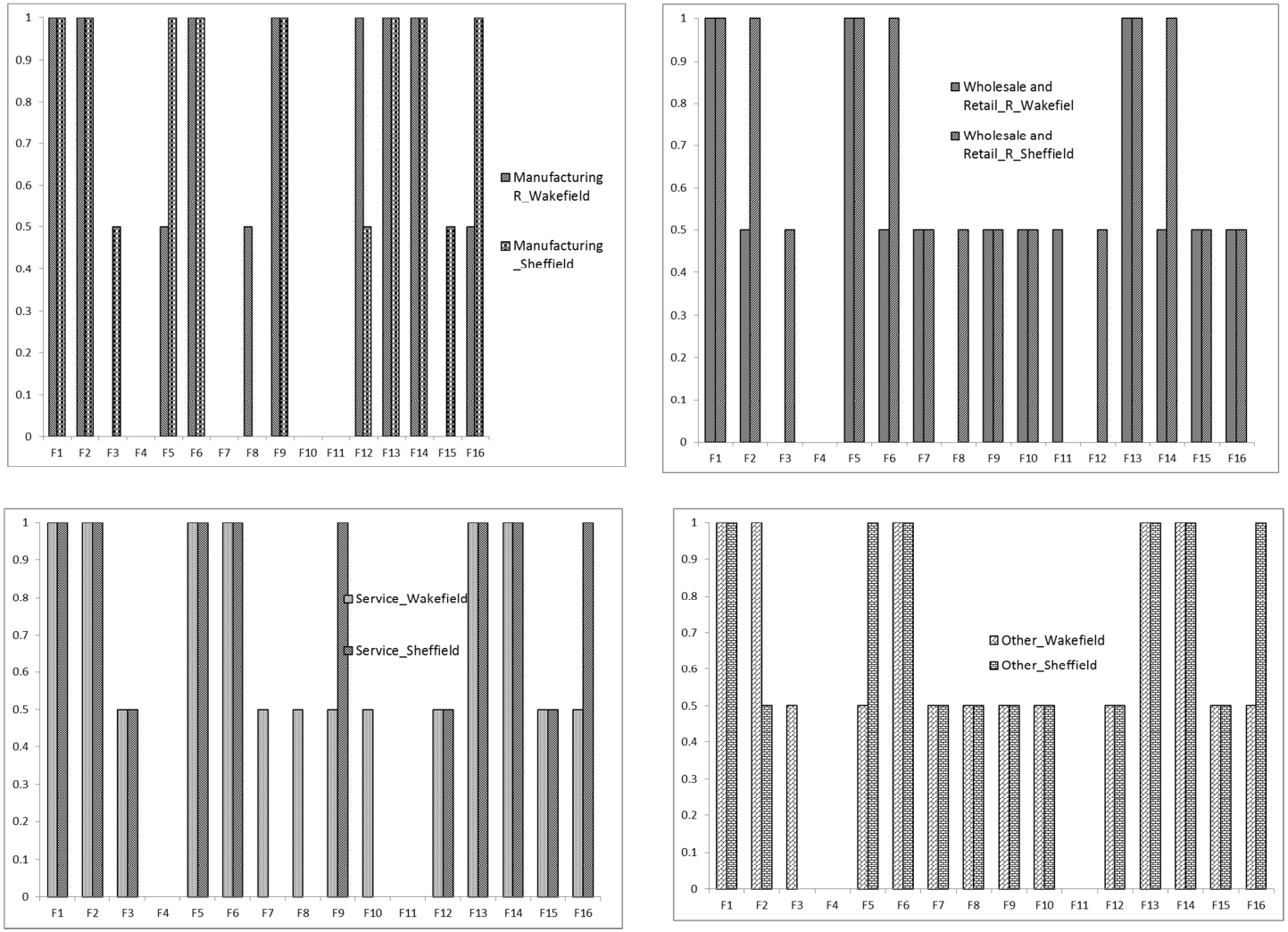


Figure 7.3 Sector specific Market perception for Vulnerability towards value

Index	Description (N=102)
F1	Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future
F2	Loss of income from high flood risk affected properties can negatively affect the demand for such properties in the real estate market
F3	Prime location of property is more important factor in determining property marketability than flood risk
F4	Easier availability of flood insurance can encourage business owners/occupiers to opt for insurance against flooding
F5	Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market
F6	Once a flood disrupted property loses its value in property market it is difficult to get higher value for the property again
F7	Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market
F8	Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding
F9	Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market
F10	Properties with history of reduced value as a result of flooding always have low demand in the property market
F11	Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future
F12	Lowering flood risk by installing resilient measures does not affect property value in the long term
F13	More loss of income during flood disruption results in longer recovery time
F14	Longer recovery time means higher loss of utility and income from the affected property
F15	Suitability for mortgage finance makes a property more attractive in the property market in spite of its high risk of flooding
F16	High flood risk and disruption of business encourages property occupiers to move out to a lower flood risk zone

Some respondents agree that steps should be taken to move out of high risk zone to zones of lower risk, but it is not a very popular idea among others, especially for wholesale and retail sector in high risk zones.

Furthermore, respondents perception of investing in properties to make it resilient to maintain its demand in the real estate market does not seem to reflect any clear perception (excepting manufacturing sector where the agreement for investing in resilient measures were higher). However it is shown clearly that if properties have chance of reduced risk the chances of getting higher value in the market is more probable. Wholesale and retail sector were mostly neutral about this issue. Therefore, the factors that surfaced as most effective in causing value to be vulnerable in the market are high flood risk status (either historical or present), potential loss of income and longer time of recovery. Geographical distribution of the vulnerability of value will be able to show the impact of perception on the flood risk status of the area. Spatial distribution of vulnerability of value for commercial properties in selected postcodes of Wakefield and Sheffield are generated as shown in Figure 7.4 and Figure 7.5.

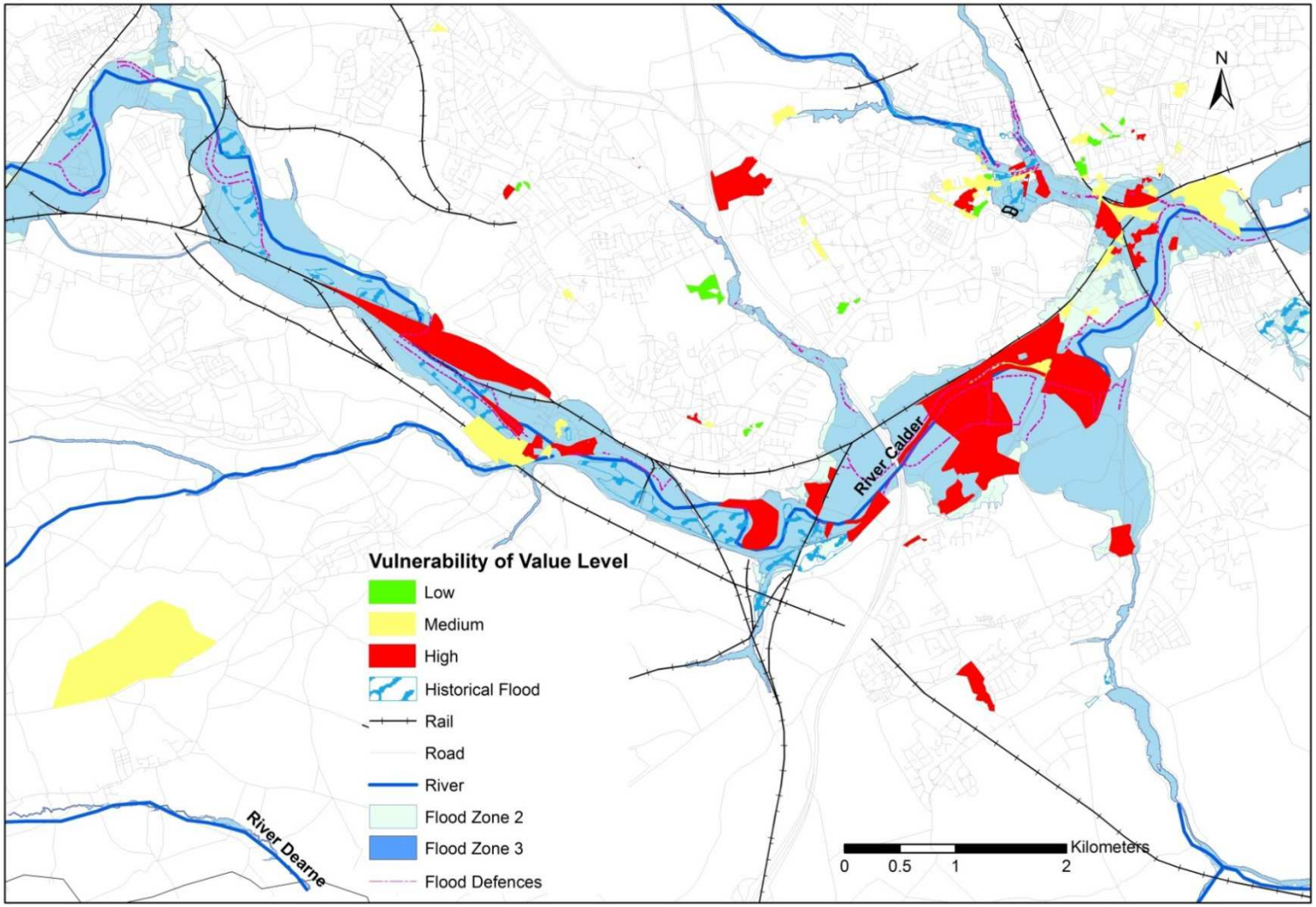


Figure 7.4 Spatial distribution of Vulnerability of value in selected postcodes of Wakefield

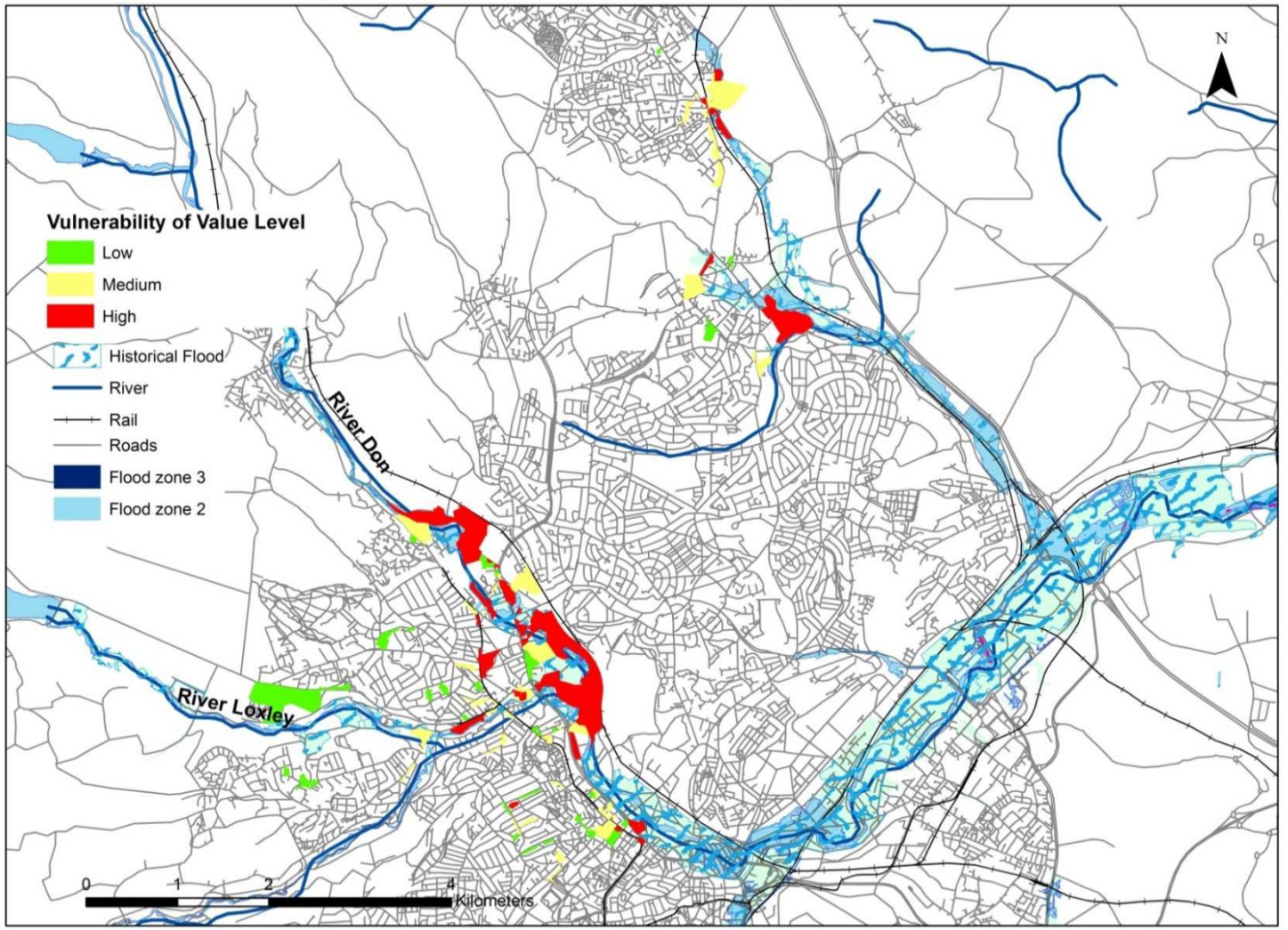


Figure 7.5 Spatial distribution of Vulnerability ofvalue in selected postcodes of Sheffield

The map indicates vulnerability of value levels in the form of traffic signal colour scheme. The green patches indicate low vulnerability; yellow patches show medium vulnerability and red patches show high vulnerability of value. These perceptions are based on how much commercial property holders are ready to pay towards value of properties with reference to differential risk status. It is observed from the distribution of vulnerability of value that direct delineation of fluvial flood risk is more visible in defining the vulnerability of value zones than business vulnerability. Observation of spatial distribution of vulnerability of value maps in both regions reveal that medium and high vulnerability of value zones are mainly spread across medium and significant risk zones (Environment Agency's flood zone 2 and 3). This distribution reflects the perception among respondents that properties at high and medium risk of fluvial flooding will experience more loss of income and subsequently lose demand in the real estate market. Properties at high risk zones are more prone to direct damage and disruption, therefore loss of income will be higher than properties outside these zones. Loss of demand in the market can make property value vulnerable in future.

According to the perception of population properties with insurance does not help in increasing their desirability in market. Although these properties are expected to reduce their recovery cost and time in future in case of another event it seems property holders' perception does not suggest this has an impact on the desirability of such properties in the market in the long term. Therefore the values of such properties are shown as vulnerable. Furthermore, areas with history of flooding are shown as more vulnerable to value than others. Respondents perceive that properties with history of flooding or once any property had renegotiations based on flood risk can never get back its value in the market. Therefore their values are permanently affected and vulnerable.

Some areas in the high and medium flood risk zones are showing lower vulnerability. These are the result of responses of respondents whose perception reflected that properties having flexible lease terms irrespective of their flood risk are worth paying higher rental value. In the business vulnerability section it was observed that specific term of lease can have significant impact on recovery time and

resilience building. But in case of vulnerability of value the reflection is different as perception is that properties with flexible lease terms are more profitable for business holders and risk of flooding is considered to be less important in comparison. Therefore property holders are ready to pay for such properties in the market and value of such properties are less vulnerable to change.

Some properties were affected by higher levels of indirect disruption and longer recovery times, however in commercial property holders perception those properties are not going to lose their value in the future because they do not have any history of direct flooding and are affected by indirect impacts. According to the respondents, such impacts are for short term and businesses can recover soon from the effect of such phenomena. As a result, the value of such properties is not considered to be vulnerable.

Majority of the respondents agree that investing in mitigation activities may have some positive impact on demand of properties nevertheless they also perceive that such demand will not be for long term. Therefore perception says expenditure on mitigation means more investment at present with no or little long term return. Therefore values of those properties are also considered to be vulnerable.

The spatial distribution of vulnerability of value maps indicates a slightly different picture from business vulnerability.

Figure 7.6 shows the differences between business vulnerability and vulnerability of value of property according to respondents' market perception.

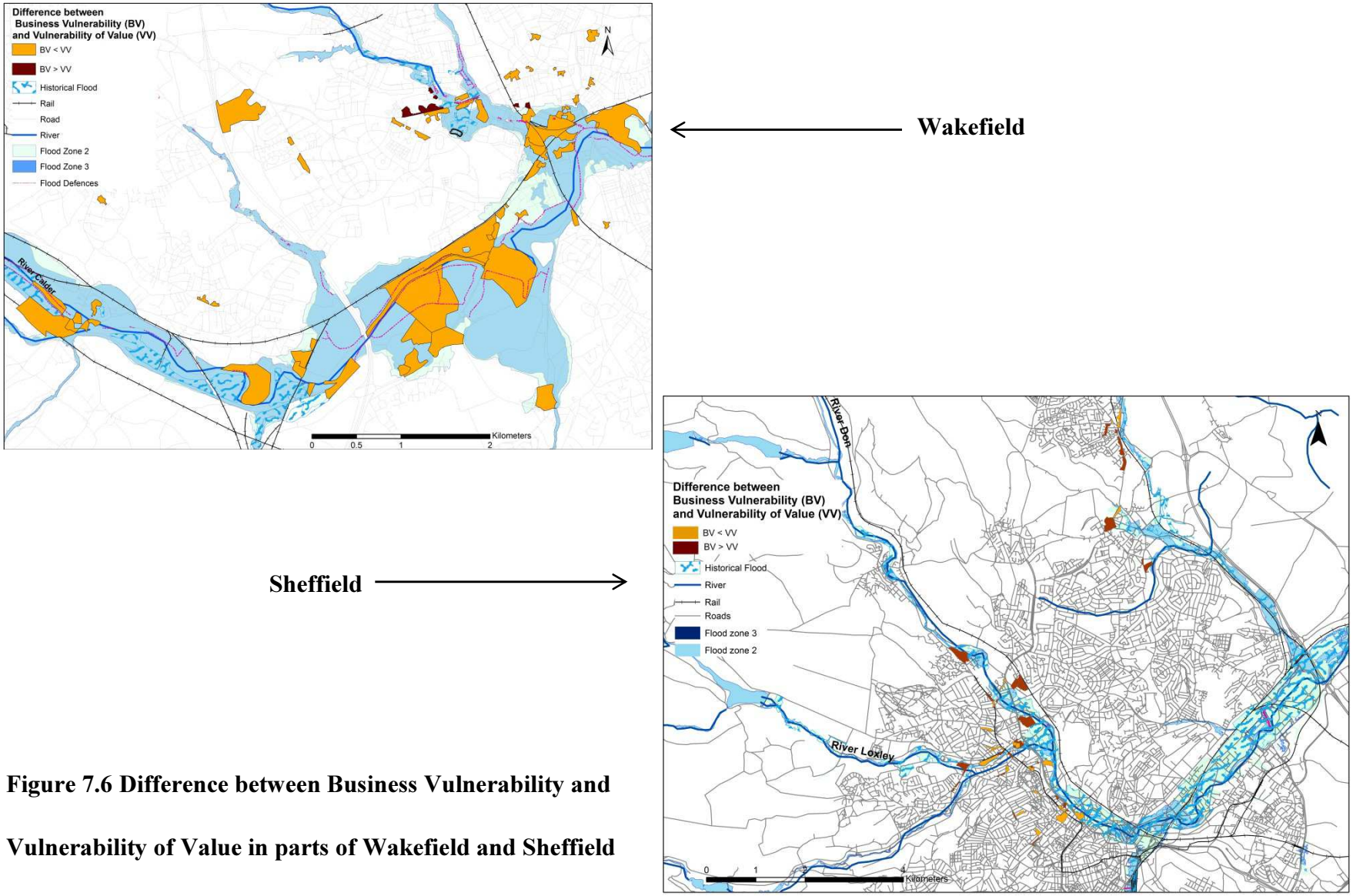


Figure 7.6 Difference between Business Vulnerability and Vulnerability of Value in parts of Wakefield and Sheffield

In

Figure 7.6 areas shown in gold have more vulnerability to value than actual business vulnerability. Areas showing higher business vulnerability levels than vulnerability of value are shown in dark brown. The perception of what makes a property value vulnerable of all sectors in commercial properties relates to high risk of flooding and subsequent effect on reduced utility of property. Therefore most of the areas with high level of vulnerability of value are in medium and high risk zones as expected. These are the same areas where business vulnerability levels are mostly lower than vulnerability of value.

Preparedness and protection level, and factors such as characteristics of businesses and financial sources of recovery helped in reducing business vulnerability in areas where business vulnerability is lower than vulnerability of value. However, these areas of lower business vulnerability are not reflected in lower vulnerability of value due to differences in market perception. People often perceive value of properties not based on what is actually existing through due diligence, rather they develop their concepts based on general viewpoint about existing risk of flooding or historical flooding. It is interesting to note that the areas where business vulnerability is higher than vulnerability of value are much smaller in number than its counterparts.

The areas where perception of vulnerability of value is showing higher effects are generally at high risk. Respondents in some of these areas showed that their businesses have been protected by preparedness measures. As a result these areas are shown at low level of business vulnerability but medium to high level of vulnerability of value.

The impact of other sources of flooding such as surface water and ground water floods are still thought to be short term events and are considered to be less impactful than river flooding. Therefore properties not at risk from rivers but flooded are more prone to higher business vulnerability but less to vulnerability of value because they are perceived as safe in commercial property holders perception. The vulnerability of value of such properties is lower.

In most cases the differences in vulnerability towards value was the result of perception of stigma generated from historical flooding. The four sectors agreed to the factor of historical flooding to be an important aspect in making value vulnerable in the market. Therefore properties affected by flooding or at high risk of flooding were permanently perceived by respondents as not a good investment. Therefore all properties affected by historical flooding are considered to have high vulnerability of value.

Vulnerability of value did not seem to be affected very much by risk reduction measures. Some of the areas are protected by newly built defences, however, with exception of very few instances the perception of high flood risk zone, higher expected loss of income and history of flooding overpowers the expected reduction in risk brought by the defences. To summarise, the vulnerability of value which is determined by commercial property holders perception is mostly predicted based on existing hazard status and expected direct impacts, whereas business vulnerability takes into account both direct and indirect effects of flooding along with response and mitigation measures. Therefore in spite of having a low level of business vulnerability, with different perception in the market, it is possible to have a high vulnerability of value.

7.5 RESEARCH VALIDATION

The strategy undertaken for validation of research has been discussed extensively in section 5.8. Since commercial property occupiers from two case study areas were used for data analysis, it was possible to compare responses from one area to another. However this perspective was predominantly from the demand side of the property market. Since value of properties also involve the supply side, it was essential to understand not only what stakeholders at the demand side of the value curve perceive about it but also the perceptions of those who are dealing in such properties in the supply side. Therefore commercial property experts from market were contacted to validate some of the factors that surfaced from the analysis of data collected from the commercial property respondents.

A total of 200 survey questionnaires were sent to property agents via email through the survey monkey portal. The responses from the email survey are expected to identify the wider knowledge of the property experts as stakeholders and to understand their experience of dealing in properties of varied risk in the real estate market. The variation in sample responses was expected to give an idea of the landlords and tenants perspectives and capture wider views from both the demand and supply side of the property market. Statistical analysis was undertaken to measure the central tendency of responses. Response from 11 experts were received which was useful for validating the outputs from the property occupiers questionnaires. Those experts who did not respond or informed that they were unable to help was mostly because they were not experienced enough with dealing in flood affected properties. A general lack of experience in dealing with flood affected property could be observed.

The summary of respondents years of experience in the commercial property real estate industry show 37% of the total respondents have experience of more than 20 years while 54% have experience between 6-10, 11-15 and 16-20 years (18% each). About 9% of the respondents have experience of 1-5 years. This demonstrates that the majority of the respondents are well experienced in dealing in the commercial property sector. However these agents showed a general lack of experience in dealing with properties affected by perceived risk of flooding. Comments from the property experts were incorporated in the survey through the spaces provided for the respondents to provide extra information. The collected data from the questionnaires shows that in their entire career of dealing in commercial property sector which was on an average 18 years their portfolio contained between 0.5 to 2% of properties affected by flooding. When this is combined with the low response rate to the survey it demonstrates a general lack of awareness of, and interest in, the issue of flood risk in commercial property. A tentative conclusion from this is that flood risk is not being considered as an important factor in commercial property transactions at present. Respondents were asked to estimate the potential changes in commercial property value with reference to change in flood risk status. The responses gained with special reference to flood defences are as follows (see Table 7.6):

Table 7.6 Reported impact of flood risk on commercial property value (Lamond et al., 2013)

	Rental Value			Sales Value		
	Without defences	**With defences**	**Difference**	**Without defences**	**With Defences**	**Difference**
Median impact of significant flood risk value %	30.5	8.0	22.5	28	10	17.5
Median impact of moderate flood risk value %	13	8	5	8	8	0

The expectation for experts is that there is potential for flood risk to have severe impact on property value. In comparison, few actual renegotiations were reported which involved impact of perceived risk of flooding on property value. This finding corresponds with the finding from the property occupiers where responses towards negotiation of property value as a result of flooding were very low, however the situation cannot be neglected just because the number of negotiations were few. Some of the following examples provided by the respondents show the situation. One respondent indicated that the perceived risk of flooding "*did not have any significant impact on value but it required the buyer to do further due diligence into the property*".

Another respondent had sale of a property refused due to perceived risk of flooding. In another example the respondent explained "*landlord offered to pay the addition to the insurance premium that the risk of flooding attracted rather than invoice the tenant for the whole amount*". For another property the "*property is let at*

a rent which reflects its potential to flooding and in view of the recent flooding on several occasions the council has shared with tenant in the cost of installing a flood barrier". Commenting on sale of another property one of the respondents highlighted that "*bids have been received and a sale price agreed subject to deduction of a sum for any abnormal costs of developing the site due to its location in the flood plain.*"

Lastly, one of the property experts' explained that they were at the receiver's end of a transaction and dealt with a bank who "*accepted that realizable value was compromised by perceived flood risk*". These examples illustrate that the process of negotiation around commercial property transactions allows for multiple approaches to dealing with perceived flood risk on the rare occasion that it arises. Therefore the fact that value impacts are not measurable in reported rental or sale price is not remarkable and the approach of using the views of property experts to identify potential impacts is justified. As a result of this the stated expectation of property impact in Table 7.6 can be seen as a future potential rather than as a market observation of present experience and may be viewed as an over estimate of current market impact.

Respondents were asked to indicate their perception of selected variables and their impacts on property value. The outcome from this exercise was to compare perception of experts to that of property occupiers' criteria's and their impacts on property value. The criteria included were high flood risk, mitigation measures, flood history, history of reduced value due to flooding. Figure 7.7 illustrates the comparative perception of respondents from both study areas and the commercial property experts. The responses were based on a 5 point Likert scale where a value less 3 indicated lower agreements and value above 3 indicated higher rate of agreement and 3 being neutral.

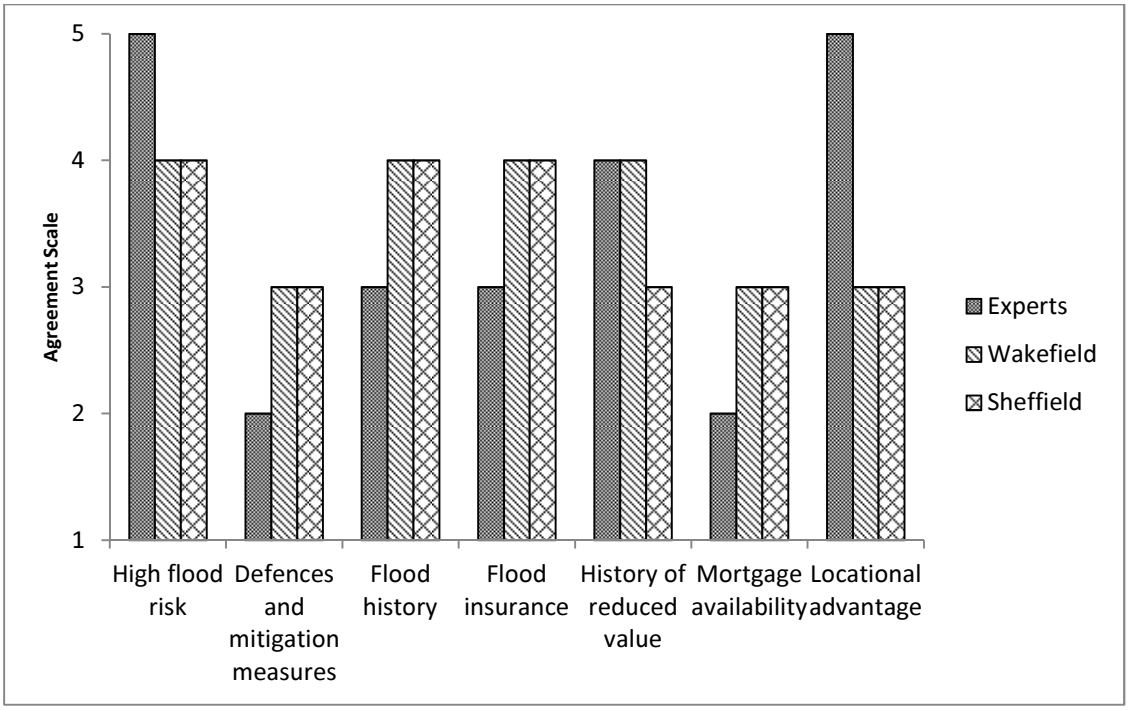


Figure 7.7 Comparative analysis of perception of flood risk and vulnerability of value of commercial properties

The pattern reveals that property occupiers were more prone towards keeping their opinions neutral. For instance, three out of seven instances the responses from property occupiers were neutral. The neutrality towards factors like flood defences and mitigation measures, mortgage availability and locational advantages, while the experts showed lower level of agreement towards these issues except for locational advantages. The most likely reason for such differences for existing defences and mitigation and mortgage availability can be the result of ignorance towards flood as an issue of concern in the market, therefore defences and mitigation activities were not taken to have much influence on value; as for the mortgage issue it seems that it is the economic climate that affected that perception.

The property experts' views on locational advantages (prime area properties) were high for all sectors. However property occupier's viewpoint for prime location was in majority neutral. Retail property holders showed more importance to locational factors as might be expected from them. The general perception of both experts and property occupiers agreed to the criteria of high flood risk having impact on property value showing the growing awareness among the stakeholders about

importance of flood risk. While property occupiers agreed highly towards easy and cheap flood insurance to have effect on property value, experts chose to be neutral in that issue. In case of criteria of effect of historical value reduction due to flooding in properties in the past can have higher impact on properties present value; the experts seem to have neutral view towards this as well. This can be due to the case specific nature of the issue. Sometimes based on the perception of some buyers, flood history of property can be an important aspect in negotiation of property value while for others that may not be an issue. The comparative responses from both data sources showed adequate evidence of agreement. Besides very few differences in the level of agreement the general responses of perception of property occupiers (demand side) could be understood well by gaining knowledge and perception from the supply side (from experts) of the value curve.

7.6 REFLECTION ON THE CONCEPTUAL MODEL

The present research proposed a conceptual model which represented the interplay and interdependence between many factors influencing the impact of flooding on the vulnerability of commercial property value. This multi-dimensional framework was developed in an attempt to represent the complexity involved in changing nature of flood risk and its influence vulnerable property value. The framework developed from evidence and knowledge of literature suggested that influence of flood risk on vulnerability of property value can be indicated by a function of the relationship between three elements: property usability, desirability and marketability. The conceptual model considers these elements to have dynamic simultaneous long term relationships in a high to low continuum scale to represent changing vulnerability. Data was collected from selected locations in order to verify the suggestions to provide evidence base for both theory and practice in the future.

7.6.1 Elements of the conceptual model

The elements of the conceptual model were derived from relevant literature. To provide some practical rigour and clarity from the experiences and knowledge of real world population the data collection and analysis process was performed. The

outcomes from the process have been discussed elaborately in the previous and this chapter.

The conceptual model suggested that the vulnerability of business is affected by five main factors: characteristics of business property, financial sources of recovery, preparedness level, and potential loss as a result of flooding and external market conditions. Business characteristics such as sector, ownership, age of business, location, number of employees, the pre and post disaster financial condition, and ownership status in the market were examined in real world situation. There was no straight forward evidence in literature that which of the influencing elements are more prevalent than other. Therefore the conceptual model did not claim to indicate that either. However when secondary data from the respondents were collected the factor that surfaced is that these factors are largely location and individual property specific and their effect on level of vulnerability cannot be specified in one measurable unit. The impact is unique to a scale up to individual property level. The conceptualisation of the factors affecting extent of post disaster business loss recovery were grounded with cost and time of recovery as the main criteria of analysis was clearly acknowledged by the data analysis results. However it is necessary to mention that impact of different factors changed within short distances and responses of respondents varied according to experience. Therefore ranking of the factors might change in different locations but the concept that fed in to the model proved to be appropriate.

Looking back at the concepts that identified with business vulnerability indicated financial instability and preparedness against stress like flooding to be a major aspects affecting business vulnerability. The evidence from the analysis of data indicates likewise. While there is a great deal of general factors which impacts upon financial stability and preparedness of property holders, the context in which the practice among respondents to protect their properties against risk of flooding occurs is subjective to variety of settings, communities, and cultures that are further influenced by the economic, social, political, fiscal, historical and psychological background of the area. The research shows evidences from the context in which the proposed conceptual model is tested, that is the selected two regions of England.

Such environment has boundaries and structures which can shape the platform of analysis. In this context of analysis factors such as commercial loan as a source of financial assistance proved to be insignificant as taking out loan for disaster risk reduction is not a common practice in the selected areas. Similarly, in case of preparedness measures literature revealed that conceptually the factors such as alternative location, alternative power and water back up were important for recovery but in present context the local practice among respondents did not reflect the same. It is important to reiterate that to bring organisational change in behaviour and practice the consideration of cultural and locational diversity is important and based on the proposed conceptual model the analysed data provides such reflections. The reflections are also visible in results achieved for potential loss due to flooding in diverse locations within the two study areas. It was observed that both direct and indirect effects of flooding were affected by short distances. Perception among commercial property holders also changed according to changing nature of risk and experience. Objective evidence from the data proves the theoretical core of the conceptual model based on which the research is performed.

The concept of external market condition which involves global and local economic conditions as well as renegotiation and deals based on dynamics of risk situation seem to be flourishing among the business sector. However it is noted by the response from the population (both business property holders and commercial property experts) that flooding is still considered to be a short term disorder and changing market condition may not be related to that. Some respondents however showed little interest towards the prospects of renegotiation but also emphasized that such cases are very few and the impact is still not widely visible in the market. This observation helped in providing special prominence towards identifying the importance of the conceptualisation of external market situation in the conceptual model. This finding justifies clearly that selection of the conceptual element of external market condition was appropriate for the research in spite of the lack of evidence in the current market condition, it is more appropriate for this type of research for providing futuristic knowledge of how the market is expected to behave in the future.

The conceptualisation of interlinking the level of business vulnerability with changes in vulnerability of value can be also reflected from the observations of the data analysis in a spatial manner. The interaction between the two concepts of vulnerability of businesses and vulnerability of the value of property are very sensitive to each other, however the direction of change is not uniform. The concept of interlinking them in the conceptual model has been validated by analysis and perception data collected through data collection process. The evidence suggests that there is consensus between the conceptualisation in the conceptual model, its design and execution in the secondary data collection process and the empirical findings. One of the intended outcomes of the research is to provide the academics and practitioners with a theoretical model which constitutes the holistic idea of the vulnerability of businesses and its link with vulnerability of value of property in terms of its utility, desirability and marketability. This will enable them to use the model to plan, implement and tract strategies for change in case of changing patterns of flood risk.

7.7 CHAPTER SUMMARY

The chapter summarised the analysis and findings of quantitative data collected through questionnaire survey providing evidence for patterns of vulnerability observed in the selected study areas by illustration of business vulnerability and vulnerability of value maps. The concept was based on analysing the level of business vulnerability of commercial properties and understanding the difference between business vulnerability and perception of vulnerability of value. The observed pattern of business vulnerability reflects importance of loss of income, and flood history as prominent factors affecting property utility and desirability. Utility and desirability are related to property marketability in the long run which can effectively have impact on value of property. The vulnerability of value showed a futuristic outcome of possible changes in property value.

The strategy adopted for validation of the general conceptual findings from the research also helped in identifying common grounds of agreement among commercial property occupiers and property experts. It might not be evident in market value yet but there are a few cases where commercial property holders are

taking the risk of flooding seriously and trying to renegotiate terms and prices or trying to take up due diligence of the property before going into a binding contract. A reflection of the conceptual model after the process of validation illustrated the consensus between theory and empirical evidence collected from ground. In light of the insights gained from the research findings, the next chapter will draw conclusions on the entire research and make relevant recommendations for future.

CHAPTER 8. CONCLUSION AND RECOMMENDATIONS

8.1 RESEARCH SUMMARY

The research looks into the role played by flood events in affecting the level of vulnerability in commercial property businesses and their vulnerability of value. To summarize the main insights gained from the research requires revisiting where the research started. It is evident that commercial business properties play an important role in the economy of every community by providing products, services, employment, and generating revenue. Research has also suggested that flooding can cause a disruption in the continuity of business and therefore affect not only the business owner but the community as a whole. However while detrimental impact on property vulnerability and property value is often speculated in literature, research on commercial business properties as a unit of analysis has been disproportionately scarce. Such a void in knowledge domain of what affects vulnerability and value of properties, motivated the requirement for a holistic conceptual understanding to be developed. The research therefore set out to understand the multifaceted complex nature of interactions between factors affecting businesses as a result of risk of flooding. Gaining insights from this rationale, the aim of this research was to investigate the relationship between the vulnerability of commercial property value and risk of flooding.

The eight research objectives listed in Chapter 1 were formulated to achieve the aim in a structured manner combining the conceptual base of two international knowledge domains within the context of UK flood hazard scenario and property market. A brief description of all the chapters followed by the recapitulation of different research objectives along with the findings are discussed to ensure that the objectives of the research have been addressed successfully.

Chapter 1 outlined the problem of risk of flooding for commercial properties and justified the need for research in vulnerability context in detail leading the way to the research aim and objectives. The chapter also briefly described the need for

the chosen approach in order to justify the attention shift from usual market data based research towards vulnerability assessment of property value.

The comprehensive literature review in chapters 2 and 3 encompassing multiple disciplines with special reference to flooding and other natural disasters were designed to elucidate the various aspects and dimensions of vulnerability and property value. The review also covered thematic, theoretical, and methodological aspects from both quantitative and qualitative research literature. Some of the major findings are summarized in section 8.2.1. Insights from the review confirmed the major research gaps and yielded deeper and more detailed understanding of the themes relating to the research aim. Objective 1 and 2 helped in achieving this understanding.

Chapter 4 presented the conceptual framework and detailed model developed through critical evaluation of the existing knowledge based on the literature review. The development included novel aspects of conceptual research by introducing systems theory, combining different research domains of vulnerability and value, conceptual mapping and integration of the time dimension. This chapter helped in attaining objective 3. The chapter also provided effective explanation of the data to be collected using empirical research strategy for verification of the conceptual outcome.

The methodological issues found from the literature review were then discussed in chapter 5, indicating a strategy to undertake the research. The chosen research approach required conceptual approaches to be operationalised within the UK property and flooding context. Key issues arising from this challenge were to design methods for effective demonstration of concepts generated from the literature review and the conceptual model in the unique field of vulnerability of value assessment and to collect appropriate empirical data from flood affected communities. The chapter achieved objective 4.

Analysis of empirical data and reflection of the implementation of model outputs was achieved through maps for illustration purpose and then the cross validation of the outputs using another dataset were fulfilled in the chapters 6 and 7.

Complete exploration of collected data from the flood plain resident population was performed using remote questionnaire survey. The implementation of a two stage survey, collection and analysis of data, reflected upon the finding as ground truth of the conceptual outputs of research. The chapter also established model verification from another sample source of property experts dealing in commercial real estate. The inclusion of property experts provided a different perspective on the illustration of research outcome. These chapters also helped in achieving objectives 5, 6 and 7.

Finally, this chapter outlines the conclusion and recommendation for the study. The description of research findings based on which conclusions and recommendations are drawn are described in the beginning of the chapter followed by the contribution of the study towards knowledge and the major limitations, and recommendations towards future research are stated. This chapter aims to attain the final objective 8.

8.2 RECAPITULATION OF RESEARCH FINDINGS

The impact of flooding on property market value can range from negligible to severe but it definitely depends upon the severity of exposure and potential vulnerability of property value towards risk. Adequate mitigation and preparedness measures can help in managing risk; however for appropriate risk management it is essential to obtain a suitable knowledge of the exposure and vulnerability. The following section will illustrate the main aspects of research findings sequentially: first, the deductive findings from literature; second, the outcome of vulnerability analysis utilising questionnaire survey; third, a summary of outputs from analysis of business and vulnerability of property value; and lastly, the potentials of the novel method of vulnerability of value analysis is illustrated below.

8.2.1 Literature review and conceptual findings

Literature revealed that commercial properties are highly prone to the effect of business interruption and closure due to disturbance caused by flood events. Most studies on commercial property in disaster research are found to be mainly sector specific damage analysis which often neglected peoples perception in predicting

vulnerability. Literature in the valuation research hardly ever attempted to look into commercial property holders perception to investigate vulnerability of value with reference to flooding. Therefore the need for comprehensive risk analysis with attention to loss patterns, preparedness and risk perception integrating the two fields of study was identified as a gap in literature.

In understanding increased vulnerability of businesses in the commercial property sector, lack of preparedness emerged as one of the major contributing factors. The immediate effects that flooding has on vulnerable commercial property are levels of loss and damage and associated need for time to recover normal business operations. Therefore preparedness factors become very effective in risk reduction. However, it was recognised that preparedness against direct damage of flooding is not adequate for reducing loss of income and that there is a need for improved understanding of indirect disruption.

Literature suggested that property holder's perception play an important role in shaping the vulnerability of value in the market. However a gap is found which showed researches in the field of valuation study are mainly market specific where inclusion of perception is rare.

Using GIS in property research is highly recommended by past studies but it has not been used widely in property research yet. Situational data was essential in estimating the vulnerability of businesses and the vulnerability of value of commercial premises from the weightings in the relevant property market. From a methodological perspective the inclusion of hierarchical modelling in weighting the different factors of vulnerability allowed flexibility to the research. By using GIS as a tool for investigating a better understanding of representation of spatially varied vulnerability data was possible for the purpose of illustration.

In a nutshell the insights gained from literature that affected the chosen methodology was based on the concept that commercial properties are most likely to be vulnerable to flood risk and subsequent change in value based on certain main criteria. The criteria of business vulnerability can be identified based the property's flood experience; impact of flooding; preparedness against flooding; and financial

capacity to cope. Furthermore the impact on property value of vulnerable properties can be identified using the criteria like ability to negotiate the price of property in the market as a result of risk of flooding and using perception of market value to make decision on future investment. The perception was distributed among property usability, desirability and marketability factors. Market perception can affect vulnerability of value from demand and supply side of the property market. Impact of detrimental condition can linger for a long period even after the property recovers fully. It is the history of the condition, which has the potential of affecting market value in the long run making value of the property vulnerable.

8.2.2 Empirical findings on business vulnerability and market perception

The impact of flooding on properties were either direct, indirect or both. It was observed that the impact of flooding could be felt very differently by businesses even within for the same designated risk area. When compared between direct and indirect damage and disruptions, it was found that the prevalence was more towards indirect disruption. Results from the questionnaire indicated that less than 38% of the total cost of damage and losses is attributed to direct effects of flooding and the rest (62%) are recognized to be spending on indirect disruptions.

In terms of preparedness against flood risk, it was found that slightly more than half of the sample flood affected property occupiers had not taken any preparatory measures while the rest had opted for some preparedness measures mainly temporary flood installation measures on an ad-hoc basis. Time of recovery differed among affected businesses; while the majority of businesses reported that they were able to recover from flood impact within a week, some exceptions to this general trend are found. Indeed some businesses suffered long term impact of flooding and this suggests the possibility that some of those who were not able to recover finally from the impact were no longer in business and therefore not available to respond to the survey.

The source of finance for recovery from damage and disruption is dominated by self-finance. Insurance against flooding was the second most popular option for those who adopted any kind of preparedness measure; however the difference

between use of self-finance and adoption of insurance for recovery was quite wide. The reason for such behaviour was obtained from the perception of the flood plain population. Results from the perception analysis showed that the most important concern for commercial property holders in the flood plain is high risk of flooding and the potential resultant loss of income. However to make investments for risk reduction is still not a priority.

Another interesting finding is the effect of flood experience on preparedness actions. Research has shown that flood experience help in increasing risk preparedness. The research showed that although the level of preparedness is still far below expectations, there is a slight indication that commercial property holders react positively to flood experience. Some property holders are using their experience of previous flooding as a motivation for installation of flood safety measures. In case of renegotiation of flood affected properties almost all property occupiers responded that there was no such renegotiation undertaken and they have no knowledge of any value change as a result of flooding in the past. This shows that association of flood risk with value of property is still in people's mind, but not currently realized in market value.

Finally, the general tendency of agreement towards usability, desirability and marketability of properties and their impact on value among the flood plain population matched to some extent among flood affected and unaffected respondents. The majority of the respondents agreed that utility of commercial properties can be hampered by high flood risk that can result in reduced income and therefore can reduce value. However some differences based on experience of flooding surfaced among the respondents. The main factors that perception of flood affected population showed higher average agreement than non-flooded population are related to high flood risk and resultant damage and disruption and recovery time affecting property value. Flood affected population showed lower agreement towards impact of historical floods on long term demand of property in the market as expected. Alternatively, the non-flooded population showed lower average agreement than flooded population where factors like prime location, suitable mortgage terms and higher expected rate of income generation were provided as

preferable options in spite of high risk of flooding for making a property desirable in the market. Non-flooded population also agreed more towards improvement of property protection against risk of flooding that can affect property value positively in the long term than their flooded counterparts.

The responses suggest that flood plain population are gaining awareness regarding risk and importance of mitigation measures and vulnerability of property value. However, in spite of being concerned about the potential impact on income generation, risk of flooding is still not considered as important as some of the other factors affecting property utility. There is indication that flood affected population are more adapted to the vulnerable situation and are ready to take higher risk for maintaining their businesses in moderate and high flood risk areas.

It observed that no single variable from the conceptual outputs could be seen as solely responsible for affecting businesses and vulnerability of value. It is a congregated impact which is an accumulated outcome of many influencing factors. It is seen that there are differences between actual vulnerability of businesses and vulnerability of value and these are partly linked to differential risk taking attitude of flood plain population based on their knowledge and experience of flooding. It is also evident that perception plays an important role in determining the attitude of the market towards properties at different levels of flood risk. It is possible that with changing perception towards flood risk, the vulnerability of value can also change. The adopted approach of vulnerability analysis has the flexibility and potential to capture these finer differences between business vulnerability and vulnerability of value. It provides useful understanding of future directions of changes in vulnerability which cannot be observed in current market conditions. The following section discusses the major contributions of this research towards various aspects of theory and methodology.

8.3 RESEARCH CONTRIBUTION

8.3.1 Contribution to theory and understanding

The ground breaking contribution of this thesis is the coherent conceptualisation and operationalization of the vulnerability of commercial business properties towards flooding that can have an impact on future market value of property. Understanding vulnerability of property value in the context of flooding is a novel approach towards looking into the valuation problem. The use of systems theory, which is grounded on the concept that the observer concentrates on function and behaviour of the whole system in the form of explanation and understanding rather than trying to find a particular cause for a particular effect. The conceptualisation of vulnerability of value and its relation to business vulnerability is a novel concept brought forward by this research. Apart from that the incorporation of the concepts of property utility, desirability and marketability to identify property vulnerability has opened new avenues of future research. The interdisciplinary nature also opened up the scope of the research to different disciplines and diverse dimensions of knowledge.

There are some quantitative and qualitative evidences in literature related to business vulnerability and impact of flooding on market value, but the approach for which this research is noteworthy is trying to link them in a structured framework. Through the integration of two research domains of vulnerability and value which are otherwise studied separately into a multilevel conceptual model and by empirically testing it, this research is adding value to the existing literature base.

Traditionally, the concept of value was in majority of the cases associated with only market factors removing perception and behaviour from its domain. This research in accordance with its findings has affirmed that cognitive factors may not be reflected in current market behaviour but are essential in the long term. Therefore, integrating perception into salient and diverse perspectives of value and assimilating them to produce a unique concept of vulnerability of value is a major contribution to knowledge. The integrative perspective plays a complementary role to existing

market based research and provides a complete picture of the system and the various processes of commercial property and its vulnerability towards flood risk.

8.3.2 Methodological contribution

This research is one of the first which presents multilevel (hierarchical) conceptual understanding of business vulnerability of flood affected commercial properties comparing it with perception based vulnerability of value. The choice of vulnerability analysis to investigate impact of flooding on property value is a new avenue of research domain in property valuation research. The research has approached the problem from a different angle to have a holistic view of the problem. Looking at the research problem from a systems point of view was a critical initial technique for a research with such complex multifaceted variables. Representing the conceptual outcome in the form of spatial distribution model and then verifying with data collected from real estate experts helped in gaining robustness of research outcome. The robustness of the research design has affirmed both internal and external validity of the findings. The processes have been used separately in various other disciplines but integrating them together in the field of property research is a novel contribution in itself.

The inclusion of space, time and perception in the conceptual framework is one of the first attempts in the field of property research. This framework implies the incorporation of perception – the predictive aspect of the analysis through systems approach. The research has taken the approach of moving property value research away from purely positivist market measurement approach to a more interpretivist stance but still using quantitative methods.

The research has shown that it is possible to investigate the relationships between complex criteria such as flood vulnerability and vulnerability of value when both social and economic dimensions are interconnected on a single platform. Transferring concepts of spatial modelling using tools such as GIS in the context of vulnerability of value research certainly opens new avenues such as conducting scenario based studies for understanding changes in vulnerability. The methodology also provides the opportunity to understand the sensitivity of different vulnerability

factors towards changing perception of property holders and investigate them further with more populated data in different case study areas.

8.4 RESEARCH IMPLICATIONS

Much of the literature argues that the commercial sector has been neglected and that there is a need for addressing the research gap in dealing with flood risk situations and the factors affecting value in detail. There was a requirement to develop a novel aspect with innovative methodology which can be accepted as an alternative to market data research to indicate predictive understanding. This research adopted the conceptual grounds of vulnerability analysis to have a better understanding of the existing problem. Vulnerability analysis may be most useful when the changes in the market value in the context of flooding are not visible in short term but there are indications of potential change in the long run. Such situation is evident in UK property market and looking at the problem from an alternative perspective was essential. Therefore this research took a significant step forward in filling the gap in academic research.

This research has explored different aspects of flood vulnerability, business vulnerability, and vulnerability of value of properties. One of the merits of this study lie in its contribution in promoting deeper understanding of vulnerability within the system of commercial property sector in response to flood impacts. The implication of the research approach of bridging the gap in knowledge between two disciplines of flood vulnerability and valuation research would be worthwhile for the planning phases of future flood risk management policies to identify potential areas needing greater attention and strategies to value commercial properties with better ground knowledge.

Another implication of this research extends to policy makers. It is possible that policy makers can find the vulnerability analysis useful as not only the observed physical factors are represented in the analysis but the social perception of affected population can also be observed. Understanding the views of local commercial property holders even if they are not quantifiable can help in building partnerships in the future where wider group of stakeholders such as business holders, property

agents, valuers, developers, investors and local authority officials can participate in informed decision making in advance of financial investment. Such understanding can also help in educating in risk reduction strategies and help stakeholders to get over the constructed notions of safe neighbourhood or immunity against risk of flooding. It is somewhat reassuring from findings from the study that impact of flooding on property value is currently not visible in market, but the understanding is growing among commercial property sector that there might be future implications of changing vulnerability. This study emphasises the importance of external evaluation of business vulnerability rather than decision making based only on physical damage potential of the property.

The spatial distribution of vulnerability of businesses and vulnerability of value of property towards flooding are illustrated by vulnerability maps for both study areas. In the absence of visual impact of flooding on commercial property real estate market, these maps are valuable illustrations for understanding the conceptual outputs from literature and empirical verification through questionnaire enquiry. It is evident from the research that in terms of spatial distribution of business vulnerability the indirect impact of flooding is more apparent than direct effects. It can be clearly seen that those areas delineated by the Environment Agency as zone of significant risk are not always the areas with highest level of business vulnerability. Most areas showed impact of mixed sources of flooding.

One of the major implication of the study is the illustration assisted understanding of not only the distribution of vulnerability according to designated risk but also according to people's risk perception. The vulnerability of value maps showed a slightly different picture than business vulnerability maps. Unlike business vulnerability they are more concentrated in and around high and medium flood risk areas and signified the impacts of potential direct impacts of flooding. These maps have potential uses in planning, property and asset management, priority based investment which requires concentration on more vulnerable areas or assisting in valuation of properties based on their level of vulnerability. Understanding perception of value from commercial property holders' point of view together with the vulnerable situation of businesses with flood experience on the ground can be

very helpful for valuers. It can reduce the amount of assumptions made by valuers in valuing properties in the absence of adequate ground information.

The summary of implications provided here suggests productive avenues for research and development in the future. The illustrated maps of vulnerable regions at a post code level helped in illustrating the potentials of the conceptual model to show the relationship between vulnerability of businesses and perception based vulnerability of value of commercial properties. Due to the flexible nature of the analysis it is possible to generate scenario based information to transfer the outputs in other locations with different settings. Such transferability can have future implications on generation of a database with both business vulnerability and perception based vulnerability of value data for simulating predictive scenarios for the future.

8.5 DISSEMINATION OF RESEARCH

The research findings in various stages have been presented in international conferences and peer reviewed journals. Part of the research work was associated with Environment Agency projects and two reports and a webinar have been published internally. Sections from the research have been presented in doctoral workshops. Many oral presentations on the research have been made within and outside the University for example, at the 2014 BRE Britain “Under Water Conference” as well as presented in form of poster presentations. A list of publications from the start of the doctoral research has been attached in Appendix 8.

8.6 LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The study acknowledged that investigating vulnerability of value is a multi-faceted issue with various interrelated factors. These circumstances require a holistic approach towards understanding and reduction of vulnerability. This approach has tried to present an integrated account of influential factors on business vulnerability and vulnerability of value. It is acknowledged that the analysis was done based on knowledge gained from two areas with limited number of responses. The counter argument to that is, in situations where market reflection is not easily available,

scattered or absent this approach is ideal to gain better understanding of the overall situation.

With accumulation of larger concentration of data it is possible to obtain a richer and more informative vulnerability maps. The research design adopted for the study is robust and flexible enough to attain its aim, however within the limitations of time frame and resources it was only possible to explore responses from two study areas. The research provided a snapshot of the conceptual findings in two study areas; it is plausible that if the research is replicated in another area the findings might be different as vulnerability is area specific. On the positive side, the contribution of the research in this regard should not be underestimated as the outcome has provided a pathway to future research using more enriched dataset.

It should also be noted that each commercial property system is one of a kind and can vary with slight changes among the interaction processes. Therefore interpolation of one system over other similar system might not reflect the exact situation on the level of vulnerability. In this case the research can surely provide an idea of the cause and effect relationship based on conceptual ground. The conceptual model can therefore be customised on a case specific manner. The data used for risk categorisation is procured from Environment Agency flood risk category maps which are another source of limitation for this study. The categorisations in the maps are broad; therefore a more accurate category of risk analysis was not possible for the study. Limitation in identification of actual risk is associated with existence of other forms of flooding (such as surface water, ground water) in the surveyed areas and this data was not included in the risk delineation for analysis purposes. The data was not available from the Environment Agency during the process of analysis. However it is recognised that other forms of flooding was important and data was gathered through questionnaires and therefore have been discussed during interpretation of data.

It is also important to mention that majority of respondents described in the questionnaires their experience of 2007 flood event. This indicates the situation for that magnitude of event and the effects it had on properties for a particular event in a particular location. The ranking of the exposure and susceptibility factors for

business properties are based on the specific event. The ranking factors might differ from one place to another and change with different magnitude and frequency of flooding and give a different result. This is where the flexibility of the method lies when it is possible to update and change data and get result for any area and any location required.

The findings of the study for vulnerability of value have been based on conceptual outcome from literature review and verification was performed by personal perceptions of property occupiers and professional judgement of property experts. This can be argued that the findings might not be true reflection of reality of property value in the market. A counter argument to that is both property occupiers and experts' judgments are shaped by their experience of being at risk of flooding, or dealing properties at risk. Therefore the perception data is a reflection of their experience which makes the eventual verification of conceptual findings from literature credible. Respondents with protective measures such as property level defences or community flood defences showed less vulnerability towards business disruption therefore feeling more resilient. This interesting observation can be tested in future research to indicate whether higher level of preparedness either at property level or at a community level provide a sense of being less vulnerable towards changing property value as a result of reduced risk situation.

The convergence aspect of data collection method helped in reducing the potential biases. The adaptation of five point scales which are commonly adopted in attitude measurement data analysis may not be wide enough to capture all the subtle differences in attitude in comparison to a 7 or 10 point scale. This might have partly affected some of the extreme results. However, there is a possibility that the simplicity of the scale has helped in gaining more responses in an otherwise long and complicated questionnaire.

With the changes in current economic climate the market reflection of property value could be different from the conceptual outputs. Flood risk is one of the several factors that might affect property value; therefore it is possible that with the changing frequency and severity of flooding, the perception may change with changing economic climate. The number of responses from the two selected case

study areas can be argued as low in terms of statistical measures. However, with the pre-existing condition of scattered number of commercial properties in flood plain population and unavailability of reliable list for pinpointing properties at risk of flooding, it was evident that a larger sample of population was selected so that highest number of affected commercial property holders could be captured. This situation cannot be directly reflected with statistical analysis of response rate. On a positive note more than two hundred responses from two study areas were useful for the analysis, thus confirming the importance and credibility of the research.

8.7 RECOMMENDATIONS

- The conceptual output from the research should be used for understanding nature of vulnerability among commercial property sectors in other locations.
- More data is required for populating the postcode area which can provide a precise picture of the ground.
- Inclusion of effect of historical flooding within the commercial property system is required to identify experience based response and recovery strategies for future.
- Pointed by previous studies in residential sector, this study also recommends that concentration on repeatedly flooded properties at significant risk will be eventually beneficial for this form of research.
- Using vulnerability as a criterion for understanding fragile human-environment interaction to identify intervention strategies is a novel aspect in the research field of commercial built environment which should be further pursued for future studies.
- More concentration on offsite damages or disruptions and resilience enhancement for indirect damages is essential to protect businesses from losing income in the long run.
- More research is required integrating perception of flood affected population for better response through change in policies to understand the need of the commercial property sector.

- Weights for ranking factors affecting business vulnerability and vulnerability of value can be used for future investigations with minor locational changes. The flexibility and transferability of the research methodology is recommended to be used for future investigations.
- Transferring concepts of spatial modelling using tools like GIS in the concept of vulnerability of value research certainly will open new avenues to the future of property research domain.

8.8 CONCLUDING REMARKS

The outcome from the research indicates vulnerability of value is a function of multiple interacting drivers of flood risk. Notwithstanding the uncertainties in the analysis, the research provides important and new insights for relevant stakeholders related directly to commercial properties. It is evident from several research outputs that in coming years flood management will be accompanied with large increases in damage and disruptions and vulnerability will increase. Along with global economic change 'business as usual' will also depend on the trajectory of local socio-economic changes. The stated aim of this study was to investigate the relationship between the vulnerability of commercial property value and risk of flooding. The study has provided a significant step forward in understanding the different issues of business vulnerability and vulnerability of value. The method of vulnerability of value analysis was generated through integration of two research domains of flood vulnerability and property value. The novel methodology has opened new avenues for future research and development in this field. In a complex and dynamic field of research such as the commercial property sector, vulnerability involves interaction between physical, social and economic factors, and this research is able to present a holistic output paving the way forward for future research to develop further in this much neglected field of study.

REFERENCES

Aba-Bulgu, M. & Islam, M.N. (2007) *Corporate crisis and risk management: modelling strategies and SME application*. Oxford: Elsevier Ltd.

ABI (2008) *Revised statement of principles on the provision of flood insurance*. London.

ABI (2009) *Flooding-Information for consumers*. Available from: http://www.abi.org.uk/Information/_Insurance_Advice/_Consumers/_General/Flooding__Information_for_Consumers.aspx. [Accessed 17 January 2011].

ABI (2010a) *ABI comments on flood investment plans*. Available from: http://www.politics.co.uk/opinion-formers/press-releases/economy-and-finance/abi-comments-on-flood-investment-plans-$21384986$366385.htm [Accessed 3 March 2011].

ABI (2010b) *Spending Review – ABI comments on flood investment plans*. Available from: http://www.abi.org.uk/Media/Releases/2010/10/Spending_Review__ABI_comments_on_flood_investment_plans.aspx. [Accessed 15 February 2011].

ABI (2013) *ABI and Government agree Memorandum of Understanding on scheme to safeguard UK flood insuranc*. Available from: https://www.abi.org.uk/News/News-releases/2013/06/ABI-and-Government-agree-Memorandum-of-Understanding-on-scheme-to-safeguard-UK-flood-insurance [Accessed 30 June 2013].

Actionaid (2005) *Participatory Vulnerability Analysis - A step by step guide for field staff*. London.

Adair, A., Berry, J., Deddis, B., McGreal, S., Keogh, G. & Key, T. (1998) Barriers to data sharing in the surveying profession: implications for the commercial property market. *Journal of Property Research*. 15 (4), pp. 331–346.

Adair, A., Hutchison, N., MacGregor, B.D., McGreal, S. & Nanthakumaran, N. (1996) An analysis of valuation variation in UK commercial property market. *Joural of Property Valuation and Investment*. 14 (5), pp. 34 – 47.

Adger, W.N. (2003) Social Capital, Collective Action, and Adaptation to Climate Change. *Economic Geography*. 79 (4), pp. 387–404.

Adger, W.N. (2006) Vulnerability. *Global Environmental Change*. 16 (3), pp. 268–281.

Alesch, D.J., Holly, J.N. & Nagy, R. (1998) Small business failure, survival, and recovery: lessons from the January 1994 Northridge Earthquake. *NEHRP Conference and Workshop on Research on the Northridge*. California.

Alesch, D.J., Holly, J.N. & Nagy, R. (2001a) Organizations at Risk: What happens when small businesses and not-for-profits encounter natural disasters. *Small organizations Natural hazards project, First Year technical report*. [online]. Available from: https://www.riskinstitute.org/peri/images/file/Organizations_at_Risk.pdf.

Alesch, D.J., Holly, J.N. & Nagy, R.J. (2001b) When small businesses and not-for-profit organizations collide with environmental disasters. *First Annual IIASA-DPRI meeting on Integrated Disaster Risk Management: Reducing Socio-Economic Vulnerability*. Luxemburg.

Alwang, J., Siegel, P.B., Jørgensen, S.L. & Tech, V. (2001) *Vulnerability : A View From Different Disciplines*. World Bank Publication, Washington D.C.

Anderies, J.M., Folke, C., Walker, B. & Ostrom, E. (2013) Aligning Key Concepts for Global Change Policy: Robustness, Resilience, and Sustainability. *Ecology and Society*. 18 (2), pp. 1–16.

Ashby, W.R. (1956) *An Introduction to Cybernetics*. London: Chapman & Hall.

AXA (2009) *AXA Insurance Flood Guide: Commercial premises*. London.

AXA (2008) *Preparing for climate change: a practical guide for small businesses*. [online]. Available from: www.axa4business.co.uk. [Accessed 15 August 2011].

Balica, S. & Wright, N.G. (2009) A network of knowledge on applying an indicator-based methodology for minimizing flood vulnerability [online]. *Hydrological Processes*. 23 (20), pp. 2983–2986.

Balica, S. & Wright, G.N. (2010) Reducing the complexity of flood vulnerability index. *Environmental Hazards*. 9, pp. 321–339.

Ball, M., Lizieri, C. & MacGregor, B. (1998) *Economics of Commercial Property Markets*. [online]. Available from: http://wol.eblib.com/patron/FullRecord.aspx?p=169627. [Accessed 2 June 2011].

Barone, T.E. (1992) On The Demise of Subjectivity in Education Inquiry. *Curriculum*. 22 pp. 25–38.

Bebbington, A. (1999) Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty. *World Development*. 27 pp. 2021–2034.

Bell, R. (1996) Quantifying Diminution in Value Due to Detrimental Conditions: An Application to Environmentally Contaminated Properties. *Environmental Claims Journal*. pp. 135.

Bell, R. (1998) The Impact of Detrimental Conditions on property values. *The appraisal Journal*. 66 (4), pp. 380–391.

Berkhout, F., Hertin, J. & Arnell, N.W. (2004) *Business and Climate Change: Measuring and Enhancing Adaptive Capacity*. Technical Report No. 11 Tyndall Centre for Climate Change.

Bhattacharya, N., Lamond, J. & Proverbs, D. (2011) Flood vulnerability and hazard adjustment for UK commercial sector.In: In: R Haigh & Dilanthi Amaratunga (eds.). *Interdisciplinary approaches to disaster risk reduction, and development of suitabkle communities and cities*. 2011 Kandalama, Srilanka: University of Salford, RMIT, ISDR.

Bhattacharya, N., Lamond, J., Proverbs, D. & Hammond, F. (2011) Impact of flooding on the value of commercial properties in the UK. In: R Haigh & Dilanthi Amaratunga (eds.). *Interdisciplinary approaches to disaster risk reduction, and development of suitabkle communities and cities*. 2011 Kandalama, Srilanka: University of Salford, RMIT, ISDR.

Bhattacharya, N., Lamond, J., Proverbs, D., Hammond, F.N. & Searle, D. (2013) Development of conceptual framework for understanding vulnerability of commercial property values towards flooding. *International Journal of Disaster Resilience in the Built Environment*. 4 (3), pp. 334–351.

Bhattacharya, N., Lamond, J., Proverbs, D.G., Hammond, F. & Searle, D. (2012) A framework for participatory assessment of vulnerability of commercial property values to flooding in the UK. In: D G Proverbs Mambretti, S., Brebbia, C.A., Wrachien de, D. (ed.). *Flood recovery innovation and response (FRIAR) III*. 30 May 2012 Dubrovnik, Croatia: WIT Press.

Bird, D.K. (2009) The use of questionnaires for aquiring information on public perception of natural hazards and risk mitigation-a review of current knowledge and practice. *Natural Hazards and Earth System Science*. 9 pp. 1307–1325.

Birkmann, J. (2006) Indicators and criteria for measuring vulnerability: theoretical bases and requirements J.Birkmann (ed.). *Measuring vulnerability to natural disasters*. pp. 55–77.

BIS (2010) *SME Statistics for UK region 2008*. [online]. Available from: http://stats.bis.gov.uk/ed/sme/Stats Press release 2008 Edition - corrected version July 2010.pdf.

Blackledge, M. (2009) *Introducing Property Valuation*. Routledge. NewYork

Blanchard R. D., B., Berry, K.A. & Showalter, P.S. (2001) Should flood insurance be mandatory? Insights in the wake of the 1997 New Year's Day flood in Reno-Sparks, Nevada *Applied Geography*. 21 (3), pp. 199–221.

Bleda, M. & Shackley, S. (2008) The dynamics of belief in climate change and its risks in business organisations. *Ecological Economics*. 66 (2–3), pp. 517–532.

Bogardi, J. & Birkmann, J. (2004) Vulnerability Assessment: the First Step Towards Sustainable Risk Reduction. In: D. Malzahn & T. Plapp (eds.). *Disaster and Society. From Hazard Assessment to Risk Reduction*. 2004 Berlin: Logos Verlag Berlin. pp. 78–82.

Bohle, H.G. (2001) *Vulnerability and Criticality: Perspectives from Social Geography*.

Bohlen, C. & Lewis, L.Y. (2009) Examining the economic impacts of hydropower dams on property values using GIS. *Journal of Environmental Management*. 90 (Supplement 3), pp. S258–S269.

Bollin, C., Cárdenas, C., Hahn, H. & Vatsa, K.S. (2003) *Natural Disasters Network. Comprehensive Risk Management*. Communities and Local Governments. Banco Interamericano de Desarrollo. Washington D.C.

Booysen, H.J., Viljoen, M.F. & Villiers, D.G. (1999) Methodology for the calculation of industrial flood damage and its application to an industry in Vereeniging. *Water SA*. 25 (1), pp. 41–46.

Bosher, L., Dainty, A., Carillo, P., Glass, J. & Price, A. (2007) Integrating disaster risk management into construction: a UK perspective. *Building Research and Information*. 35 (2), pp. 163–177.

Bossel, H. (2007) *Systems and Models: Complexity, dynamics, evolution, sustainability*. Norderstedt, Germany: Books on Demand GmbH.

Bowker, P. (2007) *Flood Resistance and Resilience Solutions Defra*. An R&D Scoping Study. Defra. London.

Brewer, M.B. (2000) *Research Design and issues of validity*. H.T Reis & C.M Judd (eds.). Cambridge: Cambridge University Press.

Briguglio, L., Cordina, G., Farrugia, N. & Vella, S. (2009) Economic Vulnerability and Resilience: Concepts and Measurements. *Oxford Development Studies*. 37 (3), pp. 229–247. [Accessed 8 December 2012].

Brinberg, D. & McGrath, J.. (1985) *Validity and research process*. Beverly Hills: Sage Publications Ltd.

Britton, W., Davies, K. & Johnson, T. (1989) *Modern methods of valuation of land , houses and buildings.* Estates Gazette (ed.) London.

Bruhns, H. & Wyatt, P. (2011) A data framework for measuring the energy consumption of the non-domestic building stock. *Building Research & Information*. 39 (3), pp. 211–226.

Bryman, A. (1988) *Quantity & Quality in Social Research*. London: Unwin Hyman.

Bulmer, M. (2004) Questionnaires. In: M Bulmer (ed.). *Sage Benchmarks in Social Science research methods*. 1st edition. London: Sage Publications Ltd. pp. 355–375.

Burk, R. (2006) *Small Business Entrepreneur: Guide to Running a Small Business*. Burk Publishing.

Byrne, P. (2005) *A geography of the UK commercial property market*. [online]. Available from: http://centaur.reading.ac.uk/view/creators/90001391.html. Central Archive at the University of Reading, Reading.

Camarasa Belmonte, A.M., López-García, M.J. & Soriano-García, J. (2010) Mapping temporally-variable exposure to flooding in small Mediterranean basins using land-use indicators. *Applied Geography*. 35 (1), pp.136-145.

Cardona, O.D. (1999) *Environmental Management and Disaster Prevention: Two Related Topics: A Holistic Risk Assessment and Management Approach in Natural Disaster Management*. J. Ingleton (ed.). Tudor Rose, London.

Chang, S.E. & Falit-Baiamonte, A. (2002) Disaster vulnerability of businesses in the 2001 Nisqually earthquake [online]. *Global Environmental Change Part B: Environmental Hazards*. 4 (2–3), pp. 59–71.

Clark, M.J. (1998) Flood Insurance as a Management Strategy for UK Coastal Resilience. *The Geographical Journal*. 164 (3), pp. 333–343.

Clarke, A. & Dawson, R. (1999) *Evaluation Research: An Introduction to Principles, Methods and Practice*. London: Sage Publications Ltd.

Clayton, M.H.A. & Radcliff, J.N. (1997) *Sustainability: A systems approach*. London: Earthscan Publications limited.

Cohen, A., Doveh, E. & Eick, U. (2001) Statistical properties of the rwg(j) index of agreement. *Psychological Methods*. 6 (3), pp. 297–310.

Cohen, A., Doveh, E. & Nahum-Shani, I. (2009) Testing agreement for multi-item scales with the indices rwg(j) and ADm(j). *Organizational Research Methods*. 12 (1), pp. 148–164.

Collis, J. & Hussey, R. (2003) *Business Research: A practical guide for undergraduate and postgraduate students.* 2nd Edition. New York: Palgrave Macmullan.

Committee on Assessing the Costs of Natural Disasters (1999) *The Impacts of Natural Disasters: A Framework for Loss Estimation*. National Academy Press, Washington D.C.

Committee on Disaster Research and Social Sciences (2006) *Facing Hazards and Disasters: Understanding Human Dimensions*. Washinton D.C.: National Academy Press.

Committee on Disaster Research and Social Sciences (1999) *The Impacts of Natural Disasters*. Washinton D.C.: National Academy Press.

Common Recognised Information Programme 45 (2007) *2007 Summer floods*. [online] Available from: http://www.environmentagency.gov.uk/static/documents/Research/floodedproperties_1912897.pdf. [Accessed 8 December 2012].

Communities and Local Government (2012) *Technical Guidance to National Planning Policy Research*. London.

Connellan James, H. (1998) Estimated realisation price (ERP) by neural networks: forecasting commercial property values. *Journal of Property Valuation and Investment*. 16 (1), pp. 71–86.

Cornwall, A., Guijt, I. & Welbourn, A. (1994) *Acknowledging Process: Challenges for agricultural research & extension methodology.* I. Scoones & J. Thompson (eds.). pp. 98–117.

Correia, F.N., Fordham, M., Saraiva, M.D.G. & Bernado, F. (1998) Flood hazard assessment and management: interface with the public. *Water Resources Management*. 12 (3), pp. 209–227.

Coudouel, A. & Hentschel, J. (2000) *Poverty Data and Measurement*. Preliminary Draft for A Sourcebook on Poverty Reduction Strategies. World Bank, Washington, D.C.

Cowley, M.. (2007) *Property market forecasts and their valuation implications: A study of Brisbane central business district office market*. Queensland University of Technology.

Creswell, J.W. (2003) *Research Design: Qualitative, Quantitative, and Mixed method approaches*. 2nd Edition. California: Sage Publications.

Creswell, J.W. (2007) *Qualitative Inquiry & Research Design, Choosing Among Five Approaches*. 2nd Edition. London: Sage Publications Ltd.

Creswell, J.W. (2009) *Research Design Qualitative, Quantitative and Mixed Methods Approaches*. 3rd Edition. London: Sage Publications Ltd.

Crichton, D. (2006) *Climate Change and its Effects on Small Businesses in the UK*. AXA Insurance, London.

Crichton, D. (2007) The future of flood management in the UK. *Insurance Research and Practice*. Issue No 1, December. pp. 1–5.

Cutter, S.L. (1996) Vulnerability to Environmental hazards. *Progress in Human Geography*. 20 (4), pp. 529–539.

Cutter, S.L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E. & Webb, J. (2008) A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*. 18 (4), pp. 598–606.

Cutter, S.L., Emrich, C.T., Webb, J.J. & Morath, D. (2009) Social Vulnerability to climate variability hazards. *Final Report to Oxfam America*.

Dahlhamer, J. & D'Souza, M.J. (1997) Determinants of Business Disaster preparedness in two U.S. Metropoliton areas. *International Journal of Mass Emergencies and Disasters*. 15 (2), pp. 265–281.

Dahlhamer, M.J. & Tierney, J.K. (1996) Rebounding From Disruptive Events: Business Recovery Following the Northridge Earthquake. *Annual Meeting of the North Central Sociological Association*.

Dainty, A. (2008) Methodological pluralism in construction management research. In: A. Knight & L. Ruddock (eds.). *Advanced Research Methods in the Built Environment*. Wiley-Blackwell. pp. pp. 1–13.

Damodaran, A. (2005) *Marketability and Value : Measuring the Illiquidity Discount*. [online]. (July) pp. 1–60. Available from: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=841484 [Accessed 2 April 2012].

Davidson, R. (1997) *An Urban Earthquake Disaster Risk Index.* The John A. Blume Earthquake Engineering Center, Department of Civil Enginering, Report No. 121. Standford University.

Debrezion, G., Pels, E. & Rietveld, P. (2007) The Impact of Railway Stations on Residential and Commercial Property Value: A Meta-analysis. *The Journal of Real Estate Finance and Economics*. 35 (2), pp. 161–180.

Defra (2013) Flood defences get green light [online]. *Reducing the threats of flooding and coastal change*. 7 February. Available from: https://www.gov.uk/government/news/flood-defences-get-green-light. [Accessed 12 April 2013]

Defra & Environment Agency (2005) Improving community and citizen engagement in flood risk management decision making, delivery and flood response. *R & D Technical Report*. (SC040033/SR3). London.

DETR (2000) *Guidelines for Environmental Risk Assessment and Management* The Stationary Office (ed.). DETR., Environment Agency.,Institute of Environment and Health, London.

Dillman, D. (2000) *Mail and Internet Survey: the tailored design method.* John Wiley & Sons, Ltd. Hoboken, New Jersey.

Dinicola, K. (1996) *The 100-Year Flood - USGS fact sheet 229-96*. Available from: http:// pubs.usgs.gov/fs/FS-229-96/pdf/FS_229-96.pdf. [Accessed 11 March 2011].

Dixon, T. (2009) Urban land and property ownership patterns in the UK: trends and forces for change. *Land Use Policy*. 26 (Supplement 1), pp. S43–S53.

Dlugolecki, A. (2008) Climate Change and the Insurance Sector. *The Geneva Papers*. 33 pp. 71–90.

Doornkamp, J.C. (1998) Coastal flooding, global warming and environmental management. *Journal of Environmental Management*. 52. pp.327–333.

Downing, T. (2004) What Have We Learned Regarding a Vulnerability Science? In: *Science in Support of Adaptation to Climate Change,United Nations Framework Convention on Climate Change*. 2004 Buenos Aires: Argentina.

Drabek, T.E. (1999) Understanding disaster warning responses. *The Social Science Journal*. 36 (3), pp. 515–523.

Du, X. & Lin, X. (2012) Conceptual Model on Regional Natural Disaster Risk Assessment. *Procedia Engineering*. 45, pp. 96–100.

Duggan, O. (2013) Government spending on flood defences slammed by MPs [online]. *The Independent*. 4 July. Available from: http://www.independent.co.uk/news/uk/home-news/government-spending-on-flood-defences-slammed-by-mps-8687173.html [Accessed 12 August 2013].

Eakin, H. (2006) Assessing the vulnerability of socio-environmental systems. *Annual review of environment and resources*. 31 pp. 365–394.

Easterby-Smith, M., Thorpe, R. & Lowe, A. (2002) *Management Research: An Introduction*. 2nd Edition. London: Sage Publications Ltd.

Edie Newsroom (2013) *Government investment not sufficient to deal with rising flood risks*. Available from: http://www.edie.net/news/4/Government-investment-not-sufficient-to-deal-with-rising-flood-risks-/ [Accessed 7 July 2013].

Egan, F.K. & McGuirk, G.R. (2000) *Valuation Study: Assessment of impact of planning controls and public notifications regardingflood risks,upon property value*. Egan National Valuers, NSW Pty.Ltd

Eichholtz, P., Kok, N. & Quigley, J. (2009) *Doing Well By Doing Good? Green Office Buildings*. UC Berkeley. Berkeley

Environment Agency (2009a) *Flood risk management: the last ten years* Flood and Coastal risk management. Bristol.

Environment Agency (2009b) *Flooding in England : A national assessment of flood risk*. Bristol.

Environment Agency (2010) *The costs of summer2007 floods in England* Defra; Environment Agency (ed.). [online]. Available from: http://publications.environment-agency.gov.uk/PDF/SCHO1109BRJA-E-E.pdf [Accessed 20 November 2012].

Environment Agency (2012) *How we forecast floods, issue warnings and calculate risk*. Available from: http://www.environment-agency.gov.uk/homeandleisure/floods/31680.aspx [Accessed 20 November 2012].

European Commission (2006) *The New SME Definition: User guide and model declaration. European Commission.* http://ec.europa.eu/digital-agenda/en/news/new-sme-definition-user-guide-and-model-declaration [Accessed 7 September 2012]

Evans, E., Ashley, R., Hall, J., Penning-Rowsell, E.C., Saul, A., Sayers, P., Thorne, C. & Watkinson, A. (2004) *Foresight. Future Flooding. Scientific Summary: Future risk and their drivers*.Volume 1: Available from: http://www.bis.gov.uk/foresight/our-work/projects/published-projects/flood-and-coastal-defence/project-outputs/volume-1 [Accessed 20 February 2011].

Evans, H., Penning-Rowsell, E.C., Saul, A., Sayers, P.B., Thorne, C.R. & Watkinson, A.R. (2006) Drivers, responses and choices for future flood risk management. *Journal of Water Management*. 159 pp. 53–61.

Fernández, D.S. & Lutz, M.A. (2010) Urban flood hazard zoning in Tucumán Province, Argentina, using GIS and multicriteria decision analysis. *Engineering Geology*. 111 (1-4), pp. 90–98.

Fillenbaum, G. & Smyer, M.A. (1981) The Development, Validity, and Reliability of the Oars Multidimensional Functional Assessment Questionnaire. *Journal of Gerontology*. 36 (4), pp. 428–434.

Firth Colley, M., J. (2006) The adaptation tipping point : are UK businesses climate proof? *Acclimatise and UKCIP*. Oxford.

Floodsite (2007) *Evaluating flood damages: guidance and recomendations on principles and methods* Edmund Penning-Rowsell Frank Messner Colin Green, Volker Meyer, Sylvia Tunstall, Anne van der Veen (ed.). Report No:T09-06-01, HR Wallingford UK.

Flynn, D.T. (2007) The impact of disasters on small business disaster planning: a case study. *Disasters*. 31 (4), pp. 508–515.

Fuerst, F. & McAllister, P. (2009) Does it pay to be green? Connecting economic and environmental performance in commercial real estate markets. In: *IRES Conference*. 2009 Regensburg, Germany.

Fuerst, F., McAllister, P., Wetering, van de J. & Wyatt, P. (2010) Establishing a data framework for measuring the price effects of eco-certification. *FiBRE Series*. RICS, London.

Fuerst, F., McAllister, P., Wetering, van de J. & Wyatt, P. (2011) Measuring the financial performance of green buildings in UK commercial Property market. *Journal of Financial Management of property Construction*. 16 (2), pp. 163–185.

Fuerst, F. & McAllister, P. (2011) The impact of Energy Performance Certificates on the rental and capital values of commercial property assets. *Energy Policy*. 39 (10), pp. 6608–6614.

Gallopı´n, G. (2006) Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*. 16 pp. 293–303.

Gao, J., Nickum, J.E. & Pan, Y. (2007) An assessment of flood hazard vulnerability in the Dongting Lake Region of China. *Lakes & Reservoirs: Research & Management*. 12 (1), pp. 27–34.

Ginige, K., Amaratunga, D. & Haigh, R. (2010) Developing Capacities for Disaster Risk Reduction in the Built Environment: Capacity analysis in Sri Lanka. *International Journal of Strategic Property Management*. 14 (4), pp. 287–303.

Gissing, A. (2002) Business in the Macleay: Commercial Flood Damage Kempsey 2001. *Annual NSW Floodplain Management Conference*. Available from: http://www.ses.nsw.gov.au/multiversions/2815/FileName/Business_in_the_Macleay.pdf [Accessed 20 November 2012]

Gissing, A. (2003) Flood action plans- making loss reduction more effective in the commercial sector. *The Australian journal of emergency management*. 18 (3), pp. 1–9.

Gissing, A. & Blong, R. (2004) Accounting for variability in commercial flood damage estimation. *Australian Geographer*. 35 (2), pp. 209–222.

Glesne, C. & Peshkin, P. (1992) *Becoming Qualitative Researches: An Introduction,*. New York: Longman.

Gummesson, E. (1991) *Qualitative Methods in Management Research*. London: Sage Publications Ltd.

Hahn, H., Villagrán De León, J.. & Hidajat, R. (2003) *Indicators and other disaster risk management instruments for communities and local governments*. German Technical Cooperation Agency, GTZ.

Halcrow & DEFRA (2001) *National Appraisal of Assets at risk from Flooding and coastal erosion including the potential impact of climate change- Final report July 2001*.

Hall, J.W., Evans, E.P., Penning-Rowsell, E.C., Sayers, P.B., Thorne, C.R. & Saul, A.J. (2003) Quantified scenarios analysis of drivers and impacts of changing flood risk in England and Wales: 2030-2100. *Global Environmental Change Part B: Environmental Hazards*. 5 (3–4), pp. 51–65.

Hall, J.W., Sayers, P.B., Dawson, R.J. & Hall Sayers, P. B., Dawson, J. R. (2005) National-scale Assessment of Current and Future Flood Risk in England and Wales. *Natural Hazards*. 36 (1), pp. 147–164.

Hewitt, K. (1995) *Sustainable disasters? Perspectives and power in the discourse of calamity*. J Crush (ed.). London: Routledge.

Ho, M.-C., Shaw, D., Lin, S. & Chiu, Y.-C. (2008) How do disaster characteristics influence risk perception? *Risk analysis*. 28 (3), pp. 635–643.

Holborn, M. & Harambolos, M. (1991) *Sociology: Themes and Perspectives*. 3rd Edition. London: Collins Educational.

Holub Fuchs, S., M. (2008) Benefits of local structural protection to mitigate torrent -related hazards. In: E Beriatos C. Brebbia (ed.). *Risk Analysis VI*. 2008 Southampton: WIT Press. pp. pp. 401–411.

Horsley, G.J. (1992) Market value: the sacred cow, Journal of Property Valuation and Investment. *Journal of Property Valuation and Investment*. 10 pp. 694–700.

Howe, P.D. (2011) Hurricane preparedness as anticipatory adaptation: A case study of community businesses. *Global Environmental Change*. 21 (2), pp. 711–720.

IAAO (2001) *Standard on the Valuation of Properties Affected by Environmental Contamination*. International Association of Assessing Officers, Chicago, IL

Ibrekk, A.S., Krasovskaia, I., Gottschalk, L. & Berg, H. (2005) Perception and communication of flood risk—preliminary results from the flows project. In: *Proceedings of International Conference on Innovation Advances and Implementation of Flood Forecasting Technology*. Tromse.

ICPR (International Commission for the Protection of the River Rhine) (2002) *Non Structural Flood Plain Management – Measures and their Effectiveness*. Koblenz

Ihlanfeldt, K.R. & Taylor, L.O. (2004) Externality effects of small-scale hazardous waste sites: evidence from urban commercial property markets. *Journal of Environmental Economics and Management*. 47 (1), pp. 117–139.

Ingirige, B., Jones, K. & Proverbs, D. (2010) Building up Resilience of Construction sector SME's and their supply chains to extreme weather events. In: D.Amaratunga P. Barrett R.Haigh, K.Keraminiyage, Chaminda Pathiyrage (ed.). *CIB World Congress*. [online]. 2010 Salford, UK: University of Salford. Available from: http://www.irbdirekt.de/daten/iconda/CIB11642.pdf.

Ingirige, B., Proverbs, D. & Wedawatta, G. (2012) *Impact of flooding on SME's and their relevance to Chartered Surveyors*. RICS, London.

Ingirige, B. & Wedawatta, G. (2011) *Impacts of flood hazards on small and medium companies: Strategies for property level protection and business continuity*. C. Proverbs, D., Lamond, J., Hammond, F. & Booth (ed.). Routeledge, London.

International Valuation Standards Committee (IVSC) (2007) *International Valuation Standards*. 8th Edition. London: IVSC.

ISSMGE:Technical Committee on risk assessment and management (2004) *Risk assessment: Glossary of terms*. Available from: http://www.engmath.dal.ca/tc32/ [Accessed 22 December 2011].

Jackson, T.R. (2001) The Effects of Environmental Contamination on Real Estate : A Literature Review. *Journal of Real estate Literature*. 9 (2), pp. 93–116.

James, L.R., Demaree, R.G. & Wolf, G. (1984) Estimating within group interrater reliability with and without response bias. *Journal of applied psychology*. 69 pp. 85–98.

James, L., Demaree, R.G. & Wolf, G. (1993) rwg:An Assessment of within group interrater agreement. *Journal of applied psychology*. 78 (2), pp. 306–309.

Janssen, R. (2001) On the use of multi-criteria analysis in environmental impact assessment in The Netherlands. *Journal of Multi-Criteria Decision Analysis*. 10 pp. 101–109.

JBA Consultant (2009) *Strategic Flood Risk Assessment*. Wakefield Metropoliton District Council, Wakefield.

JACOBS (2008) *Strategic Floof Risk Assessment.* Sheffield City Council, Sheffield.

Jha, A., Lamond, J., Bloch, R., Bhattacharya, N., Papachristodoulou, N., Bird, A., Proverbs, D., Davies, J. & Baker, R. (2012) *Cities and Flooding: A guide to integrated urban flood risk management for 21st Century*. Washinton DC: GFDRR, World Bank.

Johnson, C., Penning-Rowsell, E. & Parker, D. (2007) Natural and imposed injustices: the challenges in implementing "fair" flood risk management policy in England. *Geographical Journal*. 173 (4), pp. 374–390.

Johnson, P. & Duberly, J. (2000) *Understanding Management Research*. London: Sage Publications Ltd.

Jones, K. (2012) Preparing for extreme weather events: a risk assessment approach. In: C Booth Lamond, J., Hammond, F., Proverbs, D. (ed.). *Solutions to climate change challenges in the built environment*. West-Sussex: Wiley-Blackwell. pp. 269–281.

Joseph, R., Proverbs, D., Lamond, J. & Wassell, P. (2011) An analysis of the costs of resilient reinstatement of flood affected properties: A case study of the 2009 flood event in Cockermouth. *Structural Survey*. 29 (4), pp. 279–293.

Kanbur, R. & Squire, L. (1999) *The Evolution of Thinking About Poverty: Exploring the Interactions.* World Bank, Washington, D.C.

Kappes, M.S., Papathoma-Köhle, M. & Keiler, M. (2012) Assessing physical vulnerability for multi-hazards using an indicator-based methodology. *Applied Geography*. 32 (2), pp. 577–590.

Keiler, R.M., Jörg, P., Weber, C., Fuchs, S., Zischg, A. & Sailer, R. (2006) Avalanche risk assessment - a multi-temporal approach, results from Galtür, Austria. *Natural Hazards and Earth System Sciences*. 6 pp. 637–651.

Kelman, I. & Spence, R. (2004) An overview of flood actions on buildings. *Engineering Geology*. 73 (3-4), pp. 297–309.

Kenney, S., Pottinger, G., Plimmer, F. & Pocock, Y. (2006) *Flood risk and property,impacts on commercial & residential stakeholders' strategy*. The College of Estate Management, Reading.

Kerlinger, F.N. & Lee, H.B. (2000) *Foundations of Behavioural Research*. 4th Edition. Philadelphia: Harcourt College Publishers.

King, D. (2000) You're on your own: community vulnerability and the need for awareness and education for predictable natural disasters. *Journal of Contingencies and Crisis Management*. 8 (4), pp. 223–228.

Klein, K.J., Dansereau, F. & Hall, R.J. (1994) Levels issues in theory development, data collection and analysis. *Academy of Management Review*. 19 pp. 195–229.

Kozlowski, S.W.J. & Hattrup, K. (1992) A disagreement about within-group agreement: Disentangling issues of consistency versus consensus. *Journal ofApplied Psychology*. 77 pp. 161–167.

Krasovskaia, I. (2005) *Perception of Flood Hazard in Countries of the North Sea Region of Europe*. Norwegian Water Resources and Energy Directorate, Oslo.

Kreibich, H., Müller, M., Thieken, A.H. & Merz, B. (2007) Flood precaution of companies and their ability to cope with the flood in August 2002, Germany. *Water Resourses.Res.* 43, W03408, GFZ Potsdam.

Kreibich, H., Seifert, I., Merz, B. & Thieken, A.H. (2010) Development of FLEMOcs-a new model for the estimation of flood losses in the commercial sector. *Hydrological Sciences*. 55 (8), pp. 1302–1314.

Kroll, C., Landis, J., Shen, Q. & Stryker, S. (1990) The economic impacts of the Loma Prieta earthquake: a focus on small business. *Berkeley Planning Journal*. 5 (1), pp. 39–58.

Kron, W. (2002) Keynote lecture: flood risk = flood risk 9 exposure 9 vulnerability. In: B. Wu, Z. Huang, G. Wang, G. Huang, H. Fang, & J. Huang (eds.). *Flood defence 2002: proceedings of the second international conference on flood defence*. 2002 Beijing: Tsinghua University, Science Press New York Ltd. pp. 82–97.

Kuhlicke, C., Scolobig, A., Tapsell, S., Steinfuehrer, A. & De Marchi, B. (2011a) Contextualizing social vulnerability: findings from case studies across Europe. *Natural Hazards*. 58 (2), pp. 789–810.

Kuhlicke, C., Steinführer, A., Begg, C., Bianchizza, C., Bründl, M., Buchecker, M., De Marchi, B., Di Masso Tarditti, M., Höppner, C., Komac, B., Lemkow, L., Luther, J., McCarthy, S., Pellizzoni, L. (2011b) Perspectives on social capacity building for natural hazards: outlining an emerging field of research and practice in Europe. *Environmental Science & PolicyPolicy*. 14 (7), pp. 804–814.

Lake, I.R., Lovett, A.A., Bateman, I.J. & Langford, I.H. (1998) Modelling environmental influences on property prices in an urban environment. *Computers, Environment and Urban Systems*. 22 (2), pp. 121–136.

Lamond, J. & Bateman, I. (2011) *Solutions to climate change challenges in the built environment*. C. Booth, F. Hammond, J Lamond, & D Proverbs (eds.). Wiley-Blackwell.

Lamond, J., Bhattacharya, N., Squires, G. & Everrett, G. (2013) *Impact of flood defences on property values, regeneration and development*. Environment Agency internal publication. Bristol.

Lamond, J., Dhonau, M., Rose, C. & Proverbs, D.E. (2009) Overcoming the barriers to installing property level flood protection - an overview of successful case studies. In: *Road map towards Flood resilient urban environment*. 2009 Paris: Urban flood management cost action group C22.

Lamond, J., Proverbs, D., Booth, C. & Hammond, F. (2011) *Flood hazards: Impacts and responses for the built environment*. CRC Press Taylor and Francis Group, Florida.

Lamond, J., Proverbs, D. & Hammond, F. (2010) The Impact of Flooding on the Price of Residential Property: A Transactional Analysis of the UK Market. *Housing Studies*. 25 (3), pp. 335–356.

Lamond, J.E. (2008) *The impact of flooding on the value of residential property in the UK*. Wolverhampton: University of Wolverhampton.

Lamond, J.E. & Proverbs, D.G. (2006) Does the price impact of flooding fade away? *Structural Survey*. 24 (5), pp. 363–377.

Lamond, J.E. & Proverbs, D.G. (2009) Resilience to flooding: lessons from international comparison. *Proceedings of the ICE - Urban design and Planning*. 162 (2), pp. 63–70.

Lamond, J.E., Proverbs, D.G. & Hammond, F.N. (2009) Accessibility of flood risk insurance in the UK: confusion, competition and complacency. *Journal of Risk Research*. 12 (6), pp. 825–841.

Lamond., Proverbs, D., Antwi, A., J. (2007) The impact of flood insurance on residential property prices: towards a new theoretical framework for the UK market. *Journal of the Financial Management of Property and Construction*. 12 pp. 129–137.

Lin, S., Shaw, D. & Ho, M.-C. (2007) Why are flood and landslide victims less willing to take mitigation measures than the public? *Natural Hazards*. 44 (2), pp. 305–314.

Lindell, M.K. & Prater, C.S. (2003) Assessing community impacts of environmental disasters. *Natural Hazards Review*. 4 (4), pp. 176–185.

Lipsey, R.G., Langley, P.C. & Mahoney, D.M. (1985) *Positive Economics for Australian Students*. Weidenfeld & Nicolson.

Lorenzoni, I., Jordan, A., Hulme, M., Kerry Turner, R. & O'Riordan, T. (2000a) A co-evolutionary approach to climate change impact assessment: Part I. Integrating socio-economic and climate change scenarios. *Global Environmental Change*. 10 (1), pp. 57–68.

Lorenzoni, I., Jordan, A., O'Riordan, T., Turner, R.K. & Hulme, M. (2000b) A co-evolutionary approach to climate change impact assessment:Part II. A scenario-based case study in East-Anglia(UK). *Global Environmental Change*. 10 pp. 145–155.

Lucko, G. & Rojas, E.M. (2010) Research Validation: Challenges and Opportunities in the Construction Domain. *Journal of Construction Engineering and Management.* 136 (1), pp. 127–135.

Macmillan, S., Steele, J., Austin, S. & Kirby, P. (2001) Development and verification of a generic framework for conceptual design. *Design Studies*. 22 (2), pp. 169–191.

Mansuri, G. & Healy, A. (2000) *Assessing Vulnerability: An Ex ante Measure and its Application Using Data from Rural Pakistan.* Development Research Group, The World Bank, Washington D.C.

Marsh (2011) *Sustainability: The changing climate of risk.* Available from: http://documents.marsh.com/documents/SustainablityChangingClimateofRisk03-30-11.pdf [Accessed 15 July 2011].

Marsh, T., Hannaford, J., Llewellyn, P.N., Lane, P.H. & Lees, P.M. (2007) *The summer 2007 floods in England & Wales – a hydrological appraisal*. Centre for Ecology and Hydrology pp. 32.

Martin, B. (1996) Technological Vulnerability. *Technology in Society*. 12 (4), pp. 511–523.

Masozera, M., Bailey, M. & Kerchner, C. (2007) Distribution of impacts of natural disasters across income groups: a case study of New Orleans. *Ecological Economics*. 63 (2-3), pp. 299–306.

Matt, H. (2007) *Climate change adaptation for UK businesses* Cathy Durtson (ed.) Michael CBI and task force Research Centre, Exeter.

McKintire Crocker, G. C., Peters , E., D. (2010) Addressing vulnerability through an integrated approach. *International Journal of Disaster Resilience in Built Environment*. 1 (1), pp.50-64.

McLaughlin, P. & Dietz, T. (2008) Structure, agency and environment: Toward an integrated perspective on vulnerability. *Global Environmental Change*. 18 (1), pp. 99–111.

Merz, B., Kreibich, H., Schwarze, R. & Thieken, A. (2010) Assessment of economic flood damage. *Natural Hazards Earth System Science*. 10 pp. 1697–1724.

Messner, F. (2007) Evaluating Flood Vulnerability – Scope of Approaches and Challenges to Research. J Schanze (ed.). *Proceedings of European Symposium on Flood Risk Management Research*. Dresden, Germany

Messner, F. & Meyer, V. (2005) Flood damage, vulnerability and risk perception-challenges for flood damage research. *Discussion paper*. UFZ, Leipiz.

Met Office (2012) *Statistics for December and 2012: Is the UK getting wetter?* Available from: http://www.metoffice.gov.uk/news/releases/archive/2013/2012-weather-statistics [Accessed 30 March 2013].

Meusburger, K., Alewell, C. (2008) Impacts of anthropogenic and environmental factors on the occurrence of shallow landslides in an alpine catchment (Urseren Valley, Switzerland). *Natural Hazards and Earth System Sciences*. 8 pp. 509–520.

Millington, A.F. (2002) *An Introduction to Property Valuation*. 5th edition. Glasgow: Bell and Bain Ltd.

Mitchell, M. & Jolly, J. (2001) *Research design explained*. 4th edition. Fort Worth, Texas: Harcourt College Publishers.

Molinari, D. & Handmer, J. (2011) A behavioural model for quantifying flood warning effectiveness. *Journal of Flood Risk management*. 4 (1), pp. 23–32.

Moser, C. (1998) The Asset Vulnerability Framework: Reassessing Urban Poverty Reduction Strategies. *World Development*. 26 (1), pp. 1–19.

Moser, C. & Holland, J. (1997) *Household Responses to Poverty and Vulnerability. Volume 4: Confronting Crisis in Cawama, Lusaka, Zambia.* Urban Management Programme,Report 24,World Bank, Washington D.C.

Moser, S.C. (2010) Now more than ever: The need for more societally relevant research on vulnerability and adaptation to climate change. *Applied Geography*. 30 (4), pp. 464–474.

Muller, A., Reiter, J. & Weiland, U. (2011) Assessment of urban vulnerability towards floods using an indicator-based approach – a case study for Santiago de Chile. *Natural Hazards Earth System Science*. 11 pp. 2011–2107.

Mulligan, M.W.J. (2004) Modelling and model building. In: J. Wainwright & M. Mulligan (eds.). *Environmental Modelling: Finding Simplicity in Complexity*. Chichester: Wiley. pp. pp. 7–73.

Mundy, B. (1990) The impact of hazardous materials on Property Value. *The appraisal Journal*. 60 (2), pp. 155–162.

Mundy, B. (1992) Stigma and Value. *The appraisal Journal*. 60 (1), pp. 7–13.

Nachmias-Frankfurt, C. and Nachmias, D. (1996) *Research Methods in Social Science*. 5th Edition. London: Arnold.

Nicholas, J., Holt, G.D. & Proverbs, D.G. (2001) Towards standardising the assessment of flood damaged properties in the UK. *Structural Survey*. 19 (4), pp. 163–172.

Nichols, W. (2014) *Flooding: UK economy among the world's most vulnerable*. Available from: http://www.businessgreen.com/bg/analysis/2329570/flooding-uk-economy-among-the-worlds-most-vulnerable [Accessed 21 March 2014]

NRE (2000) *Rapid Appraisal Method (RAM) for Floodplain Management*. [online]. Available from: http://www.water.vic.gov.au/__data/assets/pdf_file/0019/15265/RAM-Report.pdf. [Accessed 2 March 2011]

O'Brien, K., Leichenko, R., Kelnar, U., Venema, H. & Aandahl, G. (2004a) Mapping vulnerability to multiple stressors:climate change and globalization in India. *Global Environmental Change*. 14 pp. 303–313.

O'Brien, K., Sygna, L. & Haugen, J.E. (2004b) A multi-scale assessment of climate change and vulnerability in Norway. *Climate change*. 64 pp. 195–225.

O'Connor, R.E., Yarnal, B., Dow, K., Jocoy, C.L. & Carbone, G.J. (2005) Feeling at risk matters: water managers and the decision to use forecasts. *Risk analysis : an official publication of the Society for Risk Analysis*. 25 (5), pp. 1265–1275.

Office of National Statistics (2007) *UK Standard Industrial Classification 2007 (UK SIC 2007)*. Available from: http://www.ons.gov.uk/ons/guide-method/classifications/current-standard-classifications/standard-industrial-classification/index.html [Accessed 20 October 2012].

Oliver, L. & Hayne, J. (2012) *Banking on Insurance*. Estates Gazette. pp. 87.

Oppenheim, A. (1992) *Questionnaire design, interviewing and attitude measurement*. London: Continuum.

Osborn, T. & Maraun, D. (2008) *Changing intensity of rainfall over Britain*. 2008 pp. 1–7.

Pagourtzi, E., Assimakopoulos, V., Hatzichristos, T. & French, N. (2003) Real estate Appraisal: A review of valuation Methods. *Journal of Property Investment and Finance*. 21 (4), pp. 383–401.

Pansiri, J. (2005) Pragmatism: A methodological approach to researching strategic alliances in tourism. *Tourism and Hospitality Planning & Development*. 2 (3), pp. 191–206.

Papathoma-Köhle, M., Kappes, M., Keiler, M. & Glade, T. (2010) Physical vulnerability assessment for alpine hazards: state of the art and future needs. *Natural Hazards*. 58 (2), pp. 645–680.

Parker, J.D. (2009) Business Interruption losses gauged through site surveys. *London Flood Seminar*. Lighthill Risk Network, London

Patton, M.Q. (1999) *Qualitative Evaluation & Research Methods*. 3rd Edition. California: Sage Publications Ltd.

Patwardhan, A., Downing, T., Leary, N. & Wilbanks, T. (2009) Towards an integrated agenda for adaptation research: theory, practice and policy. *Current Opinion in Environmental Sustainability*. 1 (2), pp. 219–225.

Peacock, W.G., Morrow, B.H. & Gladwin, H. (2000) *Hurricane Andrew and the reshaping of Miami: Ethnicity, gender, and the socio-political ecology of disasters.* Miami, Florida: International University, International Hurricane Center.

Penning-Rowsell, E.C. & Chatterton, J.B. (1977) *The benefits of flood alleviation: a manual of assessment techniques*. Aldershot, UK: Gower Technical press.

Penning-Rowsell, E.C. & Parker, D.J. (1987) The indirect effects of floods and benefits of flood alleviation: evaluating the Chesil Sea Defence Scheme. *Applied Geography*. 7 (4), pp. 263–288.

Penning-Rowsell, E., Tunstall, S., Johnson, C. & Wilson, T. (2006) Development of economic appraisal methods for flood management and coastal erosion protection. *R & D Technical Report* No:FD2014/TR2 Defra, EA, London.

Penning-Rowsell, E., Viavattene, C., Pardoe, J., Chatterton, J., Parker, D. & Morris, J. (2010) *The benefits of flood and coastal risk management: a handbook of assessment techniques.* London.

Pidd, M. (2009) *Tools for Thinking: Modelling in Management Science*. 3rd Edition. Wiley-Blackwell.

Pitt, M. (2008) *The Pitt Review- Learning Lessons from the 2007 floods*. Defra & Environment Agency, London.

Polsky, C., Neff, R. & Yarnal, B. (2007) Building comparable global change vulnerability assessments:The vulnerability scoping diagram. *Global Environmental Change*. 17 pp. 472-485.

Pompe, J.J. & Rinehart, J.R. (2008) Mitigating damage costs from hurricane strikes along the southeastern U.S. Coast: A role for insurance markets. *Ocean & Coastal Management*. 51 (12), pp. 782–788.

Pottinger, G. & Tanton, A. (2011) *Waterproof - Floodrisk and due diligence for commercial property investment in the UK*. The College of Estate Management, Reading.

Pottinger, G. & Tanton, A. (2012) Flooding and commercial property investment-what is the risk? *European Real Estate Society - 19th Annual Conference*. Paper 166, Edinburgh.

Powell, F. & Hardin, A. (2009) Business Recovery and the Rebuilding of Commercial property. In: *Proceedings of Shaken up*. [online]. 2009 Gisborne: Available from: http://www.gdc.govt.nz/earthquake-research/ [Accessed 17 October 2012].

Powell, T.C. (2001) Competitive advantage: logical and philosophical considerations. *Strategic Management Journal*. 22 (9), pp. 875–888.

Priest, S.J., Clark, M.J. & Treby, E.J. (2005) Flood insurance: the challenge of the uninsured. *Area*. 37 (3), pp. 295–302.

Pritchitt, L., Suryahadi, A. & Sumarto, S. (2000) *Quantifying Vulnerability to Poverty: A Proposed Measure, Applied to Indonesia.* Policy Research Working Paper #2437, World Bank, Washington D.C.

Proverbs, D. & Soetanto, R. (2004) *Flood Damaged Property: A Guide to Repair.* Blackwell Publishing Ltd. London

Proverbs, D. & Soetanto, R. (2006) Repairing flooded buildings: An insurance industry guide to investigation and repair. In: *Flood Repairs Forum*. Watford: BRE Press.

Proverbs, D., Brebbia, C.A. & Penning-Rowsell, E. (2008) Flood Recovery, Innovation and Response. *WIT Transactions on Ecology and the Environment*. Southmpton,UK.

Proverbs, D. & Lamond, J. (2008) The barriers to resilient reinstatement of flood damaged homes. *4th International i-Rec conference 2008 .Building Resilience: acheiving effective post-disaster reconstruction*. Christchurch, New Zealand.

Pryce, G., Chen, Y. & Galster, G. (2011) The Impact of Floods on House Prices: An Imperfect Information Approach with Myopia and Amnesia. *Housing Studies*. 26 (2), pp. 259–279.

Quarantelli, E.L. (1982) Sheltering And Housing After Major Community Disasters: Case Studies And General Observations. *DRC Final Project report 29*.University of Delaware, Delaware.

Raaijmakers, R., Krywkow, J. & van der Veen, A. (2008) Flood risk perceptions and spatial multi-criteria analysis: an exploratory research for hazard mitigation. *Natural Hazards*. 46pp. 307–322.

Ranganath, B.J. & Rodrigues, L.. (2008) *System Dynamics: Theory and Case studies*. New Delhi: I.K.International Publishing House.

Regulation Advisory Council (2009) *Rising Levels ? Public awareness and understanding of risks from flooding*.Department of Business Innovation and Skills.UK.

Reynard, N.S., Prudhomme, C. & Crooks, S.M. (2001) The flood characteristics of large UK rivers potential effects of changing climate and land use. *Climatic Change*. 48 pp. 343–359.

RICS (1992) *Manual of valuation guidance notes.* London.

RICS (2004) *The impact of flooding on residential property values*. [online]. 2011. Available from: http://www.rics.org/site/download_feed.aspx?fileID=2716&fileExtension=PDF [Accessed 1 October 2011].

RICS (2011) *RICS Valuation Standards – Global and UK*. 7th edition. Norwich: RICS.

RICS (2012a) *A clear guide to flooding for property owners*. London.

RICS (2012b) *Property In The Economy 2012 :Key data and Statistics Executive Summary*. pp. 1–20. London.

Roddewig, R. (1996) Stigma, environmental risk and property value: 10 critical enquiries. *The Appraisal Journal*. 64 (4), pp. 375–387.

ROOTS (2010) The property implications of flood risk management, RICS practice information and guidance. In: *RICS rural research conference*. 2010 Brighton.

Rose, A. & Lim, D. (2002) Business interruption losses from natural hazards: conceptual and methodological issues in the case of the Northridge earthquake. *Environmental Hazards*. 4 (1), pp. 1–14.

Rose, C., Proverbs, D.G., Booth, C. & Manktelow, K.I. (2012) Three times is enemy action - flood experience and flood perception. In: S Mambretti D.Proverbs C.A. Brebbia, D.de Wrachien (ed.). *Flood Recovery, Innovation and Response III*. 2012 Dubrovnik, Croatia: WIT Press.

Rosen, S. (1974) Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political economy*. 82 (1), pp. 34–55.

Rubio, D.M., Berg-Weger, M., Tebb, S.S., Lee, E.S. & Rauch, S. (2003) Objectifying content validity: Conducting a content validity study in social work research. *Social Work Research*. 27 (2), pp. 94–104.

Samwinga, V., Proverbs, D. & Homan, J. (2004) Exploring the experience of UK homeowners in flood disasters. In: *COBRA 2004 : The international construction research conference of the Royal Institution of Chartered Surveyors - Responding to change.* Leeds

Saunders, M., Lewis, P. & Thornhill, A. (2009) *Research Methods for Business Students*. 5th Edition. Pearson Education, Harlow.

Savage, A. (2007) *Overview of Flooding in Warwickshire*. Warwikshire County Council.

Sayers, P. & Meadowcroft, I. (2005) RASP-A heirarchy of risk based methods and their applications Environment agency H.R.Wallingford (ed.). *40th Defra Flood and Coastal Management Conference*. York, UK Available from: http://eprints.hrwallingford.co.uk/76/.

Schmidt, F.L. & Hunter, J.E. (1989) Interrater reliability coefficients cannot be computed when only one stimulus is rated. *Journal of Applied Psychology*. 74 (2), pp. 368–370.

Schreider, S.Y., Smith, D.I. & Jakeman, A.J. (2000) Climate Change Impacts on Urban Flooding. *Climatic Change*. 47 (1), pp. 91–115.

Seifert, I., Thieken, A., Merz, M., Borst, D. & Werner, U. (2010) Estimation of industrial and commercial asset values for hazard risk assessment. *Natural Hazards*. 52 (2), pp. 453–479.

Sexton, M. (2007) *PhD Resarch: Axiological purposes, ontological cages and epistemological keys*. Research Institute for the Built and Human Environment, University of Salford.

Shadish, W., Cook, T.. & Campbell, D. (2000) *Experimental and Quasi-experimental designs for generalised causal inference*. 2nd Edition. Boston: Houghton Mifflin.

Shapiro, E., Davies, K. & Mackmin, D. (2009) *Modern Methods of Valuation*. 10th Edition. Malta: Melita Press.

Sharma, M., Burton, I., VanAalst, M., Dilley, M. & Acharya, G. (2000) *Reducing Vulnerability to Environmental Variability: Background Paper for the Bank's Environmental Strategy*. World Bank, Washinton D.C.

Silverman, D. (1985) *Qualitative Methodology and Sociology*. Gower: Aldershot.

Skyttner, L. (2002) *The general systems theory: ideas and applications*. 2nd Edition. London: World Scientific Printers.

Slovic, P., Kunreuther, H. & White, G.F. (1974) Decision processes, rationality and adjustment to natural hazards G F White (ed.). *Natural Hazards: Local, National and Global*. Oxford University Press, New York

Smith, K., Tobin, G.A. (1979) *Human Adjustment to to flood hazard*. London: Longman.

Smith, A. & Wyatt, P. (1996) Commercial property analysis and advice: Information holds the key. In: *Proceedings of the RICS cutting edge conference*. 1996 Bristol: RICS.

Soetanto, R. & Proverbs, D.. G. (2004) Impact of flood characteristics on damage caused to UK domestic properties: the perceptions of building surveyors. *Structural Survey*. 22 (2), pp. 95–104.

Spittal, M.J., McClure, J., Siegert, R.J. & Walkey, F.H. (2008) Predictors of two types of earthquake preparation: Survival activities and mitigation activities. *Environment and Behaviour*. 40 (6), pp. 798–817.

Staff, K. (2012) *Flood insurance fears for UK commercial property owners*. Available from: http://www.movehut.co.uk/news/flood-insurance-fears-for-uk-commercial-property-owners/ [Accessed 1 January 2013].

Stanley, M., Adair, A., McBurney, D. & Patterson, D. (1998) Neural Network : the prediction of residential peoperties. *Journal of Property Valuation and Investment*. 16 (1), pp. 57.

Stern, N. (2006) *Stern Review on Economics of climate change* . London.

Strunz, G., Post, J., Zosseder, K., Wegscheider, S., Muck, M., Riedlinger, T., Mehl, H., Dech, S., Birkmann, J., Harjono, H., Gebert, N., Anwar, H.., Sumaryono, Khomarudin, R., et al. (2011) Tsunami risk assessment in Indonesia. *Natural Hazards Earth System Science*. 11 pp. 67–82.

Syms, P. (1997) Perceptions of risk in the valuation of contaminated land. *Journal of Property Valuation & Investment*. 15 (1), pp. 27–39.

Tapsell, S., McCarthy, S., Faulkner, H. & Alexander, M. (2010) *Social Vulnerability and natural hazards*. Available from: http://caphaz-net.org/outcomes-results [Accessed 29 October 2011].

Telegraph, T. (2009) Cumbria flooding: residents' disbelief at scale of floods. *The Telegraph*. [online]. Available from: http://www.telegraph.co.uk/topics/weather/6612364/Cumbria-flooding-residents-disbelief-at-scale-of-floods.html [Accessed 1 March 2011].

Temple, M. & Dent, P. (1998) Economic value- Methodological Dilemma. In: *The cutting edge*. 1998 Bristol: RICS.

Thieken, A., Ackermann, V., Elmer, F., Kreibich, H., Kuhlmann, B., Kunert, U., Maiwald, U., Merz, B., Müller, M., Piroth, K., Schwarz, J., Schwarze, R., Seifert, I. & Seifert, J. (2008) Methods for the evaluation of direct and indirect flood losses. *4th International Symposium on Flood Defence*. Toronto , Ontario.

Thompson, A.A. & Strickland, A.J. (1996) *Strategic Management: Concepts and cases*. 9th Edition. Chicago: Irwin.

Thurston, N., Finlinson, B., Breakspear, R., Williams, N., Shaw, J., Chatterton, J. (2008) Developing the evidence base for flood resistance and resilience. *R & D Technical Report*. (FD2607/TR1). Defra & Environment Agency.

Thywissen, K. (2006) Components of Risk. *Studies of the University: Research, Counsel, Education- Publication series of UNU-EHS*. (2/2006) pp. 52.

Tierney, K.J. (1994) Business Vulnerability Disruption: data from the 1993 Midwest Floods : In: *41st North American Meetings of the Regional Science Association International*. 1994 Niagara Falls, Ontario.

Tierney, K.J. & Dahlamer, J. (1996) *Business Disruption, Preparedness and Recovery: Lessons from the Northbridge earthquake*. Preliminary Paper 257. Disaster Research centre, University of Delaware.

Tierney, K.J. (1997) Business Impacts of the Northridge Earthquake [online]. *Journal of Contingencies and Crisis Management*. 5 (2), pp. 87–97.

Tierney, K. & Webb, R.G. (2001) *Business Vulnerability to earthquakes and other disasters*. [online]. Available from: http://dspace.udel.edu:8080/dspace/handle/19716/729 [Accessed 1 October 2011].

Tierney, K.J. (2007) Businesses and Disasters: Vulnerability, Impacts, and Recovery. In: L. Enrico Quarantelli, Havidán. Rodríguez, & Russell R. Dynes (eds.). *Handbook of Disaster Research*. New York: Springer New York. pp. 275–296.

Tim, R. & Richard, T. (1996) Valuing contaminated land and property: theory and practice. *Journal of Property Valuation and Investment*. 14 (4), pp. 6–17.

Timmerman, P. (1981) *Vulnerability, resilience and the collapse of society*. Environmental Monograph 1, Institute for Environmental Studies, Toronto University.

Trochim, W.. M.K. (2006) *Research Methods: Knowledge base*. [online]. http://www.socialresearchmethods.net/kb/ [Accessed 25 October 2011].

Turner, R.K., Pearce, D.W. & Bateman, I.J. (1994) *Environmental Economics: An Elementary Introduction*. Hemel Hempstead: Harvester Wheatsheaf.

Turner, R.K., Lorenzoni, I., Beaumont, N., Bateman, I.J., Langford, I.H. & McDonald, A.L. (1998) Coastal management for sustainable development: analysing environmental and socio-economic changes on the UK Coast. *Geographical Journal*. 164 (3), pp. 269–281.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A. & Schiller, A. (2003a) A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences*. 100 (14), pp. 8074–8079.

Turner, B.L., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Hovelsrud-Broda, G.K., Kasperson, J.X., Kasperson, R.E., Luers, A., Martello, M.L., Mathiesen, S., Naylor, R., Polsky, C., et al. (2003b) Illustrating the coupled

human–environment system for vulnerability analysis: Three case studies. *Proceedings of the National Academy of Sciences*. 100 (14), pp. 8080–8085.

Tuuli, M. (2009) *Empowerment and Control Dynamics in Project Teams: A Multilevel Examination of the Antecedents and Job Performance Consequences*. PhD Thesis, University of Hongkong.

UKCIP (2010) *Changing Climate for Business*. 3rd Edition, Oxford.

UNISDR (2004) *Living with Risk. A Global Review of Disaster Reduction Initiatives*. Vol:1 NewYork and Geneva.

Uzielli, M., Nadim, F., Lacasse, S. & Kaynia, A.M. (2008) A conceptual framework for quantitative estimation of physical vulnerability to landslides. *Engineering Geology*. 102 (3-4), pp. 251–256.

Vatsa, K.S. (2004) Risk, Vulnerability and asset based approach to disaster risk management *International Journal of Sociology and Social policy*. 24 (10/11), pp. 1–48.

Veen, A.V.D. & Logtmeijer, C. (2005) Economic Hotspots: Visualizing Vulnerability to Flooding. *Natural Hazards*. 36 (1), pp. 65–80.

Villa, F. & McLEOD, H. (2002) Environmental Vulnerability Indicators for Environmental Planning and Decision-Making: Guidelines and Applications. *Environmental Management*. 29 (3), pp. 335–348.

De Vries, D.H. (2011) Temporal vulnerability in hazardscapes: Flood memory-networks and referentiality along the North Carolina Neuse River (USA). *Global Environmental Change*. 21 (1), pp. 154–164.

Waterstone, M. (1978) *Hazard Mitigation Behaviour of Urban Flood Plain Residents*. Institute of Behavioural Sciences, Boulder, Colorado.

Webb, G.R., Tierney, K.J. & Dahlhamer, J.M. (1999) Businesses and Disasters: Empirical Patterns and Unanswered Questions. *Preliminary paper 281*. Disaster Research Centre, University of Delaware.

Webb, G.R., Tierney, K. & Dahlhamer, J.M. (2002) Predicting long-term business recovery from disasters: A comparison of the Loma Prieta earthquake and Hurricane Andrew. *Environmental Hazards*. 4 (1), pp. 45–58.

Wedawatta, G. (2013) *Resilience of Construction SMEs to extreme weather events*. PhD Thesis, The University of Salford.

Wedawatta, G., Ingirige, B. & Amaratunga, D. (2010a) Building up Resilience of construction sector SME's and their supply chain to extreme weather events. In: *CIB*. 2010 Salford, UK: University of Salford.

Wedawatta, G., Ingirige, B. & Amaratunga, D. (2010b) Developing a conceptual framework for investigating the resilience of construction sme's and their supply chains against extreme temperature. In: *The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors*. 2010 Paris: RICS.

Wedawatta, G., Ingirige, B. & Proverbs, D. (2011) Adaptation to flood risk: the case of businesses in the UK. In: *International conference on building resilience*. 2011 Kandamala,Srilanka:

Wenk, D. (2004) Is "Good Enough" storage Good Enough for compliance? *Disaster Recovery Journal*. 17 (1), pp. 1–3.

Werritty, A., Houston, D., Ball, T., Tavendale, A. & Black, A.R. (2007) *Exploring the Social Impacts of Flood Risk and Flooding in Scotland.*

Wheater, H. & Evans, E. (2009) Land use, water management and future flood risk. *Land Use Policy*. 26 (Supplement 1), pp. S251–S264.

Wiggins, K.P. (1979) Principles of Valuation (Section I). In: *Property valuation Handbook*. Reading: College of Estate Management.

Willett, K. & Sharda, R. (1991) Using the analytic hierarchy process in water resources planning: Selection of flood control projects. *Socio-Economic Planning Sciences*. 25 (2), pp. 103–112.

Williams, L.R.R. & Kaputska, L.A. (2000) Ecosystem vulnerability: a complex interface with technical components. *Environmental Toxicology and Chemistry*. 19 pp. 1055–1058.

Winter, G. (2000) *The Qualitative Report, 4(3&4)*. Available from: http://www.nova.edu/ssss/QR/QR4-3/winter.html [Accessed 22 April 2013].

Wisner, B., Blaikie, P., Cannon, T. & Davis, I. (2003) *At Risk: natural hazards, people's vulnerability and disasters*. 2nd edition. Routledge.

World Bank (1994) *World Bank World Development Report (1994)*. Washington D.C.

Wright, A. (2008) What is the relationship between built form and energy use in dwellings? *Energy Policy*. 36 pp. 4544–4547.

Wyatt, P. (1995) Using a geographical information system for property valuation. *Journal of Property Valuation and Investment*. 14 (1), pp. 67–79.

Wyatt, P. (1996) The development of a property information system for valuation using a geographical information system (GIS). *Journal of Property Research*. 13 (4), pp. 317–336.

Wyatt, P. (2009) Replacement cost and market value. *Journal of Property Investment & Finance*. 27 (6), pp. 593–602.

Yeh, C., Willis, R., Deng, H. & Pan, H. (1999) Task oriented weighting in multi-criteria analysis. *European Journal of Operational Research*. 119 pp. 130–146.

Yoshida, K. & Deyle, R.E. (2005) Determinants of Small Business Hazard Mitigation. *Natural Hazards Review*. 6 (1), pp. 1–12.

Zabeo, A., Pizzol, L., Agostini, P., Critto, A., Giove, S. & Marcomini, A. (2011) Regional risk assessment for contaminated sites Part 1: Vulnerability assessment by multicriteria decision analysis. *Environment International*. 37 (8), pp. 1295–1306.

Zhang Lindell, M.K., Prater, C., Y. (2004) *Modeling and managing the vulnerability of community businesses to Environmental Disasters*. Hazard Reduction and Recovery Centre, Texas A & M University, Texas.

Zhang, Y., Lindell, M.K. & Prater, C.S. (2009) Vulnerability of community businesses to environmental disasters. *Disasters*. 33 (1), pp. 38–57.

APPENDIX 1: SUMMARY OF LITERATURE (ABRIDGED) HIGHLIGHTING CONTRIBUTING VARIABLES FOR VULNERABILITY ANALYSIS

Contributing variables	Influencing variables	Literature sources	Insights
Business characteristics (Economic Vulnerability)	Sector/ Exposed assets/ Age/ use	(Vatsa, 2004; Smith & Tobin, 1979; Ingirige, Jones & Proverbs, 2010; Seifert *et al.*, 2010; Zhang Lindell, M.K., Prater, C., 2004; Temple & Dent, 1998; Millington, 2002; Evans *et al.*, 2006)	Damage of exposed assets is sector specific and type of assets involved. Value of assets depend on economic condition of the market Expose can be affected by regional specifications
	Size/ Number of employee	(Alesch, Holly & Nagy, 2001a; Ingirige, Proverbs & Wedawatta, 2012; Pitt, 2008; ABI, 2010a; Dahlhamer & Tierney, 1996; Gissing & Blong, 2004; Floodsite, 2007)	The impact of flooding can be more devastating for small and medium sized businesses than larger organisations The main factors affecting smaller enterprises vulnerability are lack of sustainable buildings, and low financial capacity to recover, dependency on a smaller market for profitability, lack of resource and knowledge for capacity building.
	Ownership/ Lease terms	(Merz *et al.*, 2010; ICPR (International Commission for the Protection of the River Rhine), 2002;	Rented properties are more vulnerable than owner occupied properties Commercial properties rental lease often under internal repairing and licensing terms rather than full repair , therefore the responsibility in

		Fuerst *et al.*, 2011; Tierney & Dahlamer, 1996)	maintaining the structural integrity of the building lies in the hands of the owners Proxy for financial success of business, since owning a business means more investment, therefore owned properties are likely to get more financial support in times of need as owners have more opportunity to make structural changes in modifying their buildings for flood resilience
	Labour mobility/ replacement	(Zhang, Lindell & Prater, 2009; Kroll *et al.*, 1990; Merz *et al.*, 2010)	Less mobile labour force will suffer more in times of recovery Businesses with separate labour pool for easy replacement in times of disaster for continuous workforce supply are less vulnerable to disruption than otherwise Ability and accessibility to work remotely depending upon type of organisation is helpful in quicker and less costlier recovery
	Primary market/ dependence on other business/ spread of business	(Howe, 2011; Webb, Tierney & Dahlhamer, 2002; Balica & Wright, 2010; RICS, 2011; Zhang, Lindell & Prater, 2009)	Businesses with larger spread in primary market are able to recover faster after disaster Larger co-dependence in demand and supply in other areas can result in delay and therefore cause impacts for dependent businesses in non-flooded areas

	Location	(Messner & Meyer, 2005; Lamond *et al.*, 2011; Pottinger & Tanton, 2011; Crichton, 2006; Wyatt, 1995)(Tim & Richard, 1996; Debrezion, Pels & Rietveld, 2007; Wyatt, 1995)(Adair *et al.*, 1998)	Location can help in maximising turnover at the same time expose to risk Some locations in significant risk zones can cause problems in getting insurance Not only location of the commercial property but also locational exposure of the properties on which the business depends for its demand and supply are critical for business continuity
Financial condition/ recovery and preparedness (Economic Vulnerability, Environmental Vulnerability)	Annual turnover / Pre-disaster financial condition/ Financial sources of recovery	(Webb, Tierney & Dahlhamer, 2002; Tierney & Dahlamer, 1996; Alesch, Holly & Nagy, 2001a)	Damage and disruptions are generally reflected in annual turnover Comparison between financial condition pre and post disaster shows actual impact on business Businesses with better pre-disaster financial resources can help in faster recovery Lack or delay in getting recovery funds can slow down recovery
	Level of reconstruction (preparedness), essential	(Messner, 2007)(Ginige, Amaratunga & Haigh, 2010)(Environment Agency, 2010)(Kenney *et al.*, 2006; Soetanto	Higher capacity of reconstruction in post disaster situation is effective in reducing vulnerability Adequate provision of essential services can help in faster recovery Commercial properties with interest in implementation of flood

	services, infrastructure quality, recovery plan	& Proverbs, 2004)(World Bank, 1994)(Environment Agency, 2009a)(Kron, 2002)(Gissing, 2003)(Alesch, Holly & Nagy, 2001a)(Lin, Shaw & Ho, 2007)	hazard action plan is more popular among those who have past flood experience while others do not take it as a major threat
	Flood defences	(Hall *et al.*, 2003; Communities and Local Government, 2012; Environment Agency, 2012; Lamond *et al.*, 2013)(Hall *et al.*, 2005)(Environment Agency, 2009b)	Existing or proposed flood defences can help in reducing perception of risk reduction Existing or proposed flood defences can help in reducing vulnerability
	Insurance	(Staff, 2012; Evans *et al.*, 2006; Lamond, Proverbs & Hammond, 2009; Lamond., Proverbs, D., Antwi, A., 2007)(Kenney *et al.*, 2006; Pottinger & Tanton, 2012)(Priest, Clark & Treby, 2005)	There is threat of reduced insurance availability due to flood risk Businesses are concerned about growing insurance premium New FloodRe has totally ignored larger commercial properties and it does not clarify its situation for smaller commercial properties as well Insurance is still bundled and not many properties have separate comprehensive business continuity insurance
	Hard and soft resilient measures	(AXA, 2008)(Committee on Disaster Research and Social Sciences, 2006)(Pitt, 2008)(Bowker, 2007;	Use of hard and soft measures together is more effective in reducing vulnerability Lack of knowledge among commercial property holders regarding

		Soetanto & Proverbs, 2004)(Strunz *et al.*, 2011)(Committee on Disaster Research and Social Sciences, 1999)(Tierney & Dahlamer, 1996)	availability of different measures
Potential loss/ impact (Physical and Economic vulnerability)	Direct loss	(Thieken *et al.*, 2008; Gao, Nickum & Pan, 2007; Kelman & Spence, 2004; Tierney, 2007, 1997; Gissing & Blong, 2004)	Direct losses deal with damage caused by direct effect of flood water These type of losses are used in majority of studies as measures of risk Knowledge of direct losses can be effective for understanding future vulnerability
	Indirect loss	(Thieken *et al.*, 2008; Penning-Rowsell & Parker, 1987; Tierney, 2007, 1997; Veen & Logtmeijer, 2005)	Indirect loss factors are often ignored in literature Indirect losses ripple out of direct losses Business interruption losses are often more notable than direct losses
	Flood risk status	(Johnson, Penning-Rowsell & Parker, 2007; Lamond, 2008; Environment Agency, 2009b; Jha *et al.*, 2012; Hall *et al.*, 2005)	Environment Agency delineated flood risk zones identify fluvial risk status It does not include surface water or other sources of flooding
	Event characteristics	(Kenney *et al.*, 2006; Marsh *et al.*, 2007; Dinicola, 1996; Nicholas, Holt	Flood depth and duration can have adverse effect on the structural damage and interior disruption of property

		& Proverbs, 2001)	Understanding of frequency of flooding is a fundamental step of understanding flood risk
External condition (Social Vulnerability, Economic vulnerability)	Perception/ social factors (awareness, cognition experience and level of support)	(Rose *et al.*, 2012)(Ho *et al.*, 2008)(Peacock, Morrow & Gladwin, 2000)(Hall *et al.*, 2003; Cutter *et al.*, 2009; Ibrekk *et al.*, 2005)(Hewitt, 1995)(Lamond & Proverbs, 2009)(Drabek, 1999) (Bowker, 2007; Thurston *et al.*, 2008)(Berkhout, Hertin & Arnell, 2004)	Desirability of people to take up resilience is low as a result of differential perception of risk and unawareness Emotional constraints often led lead to cognitive factors to prevent actual risk to be perceived Previous experience help in framing perception towards resilience building With passing time people tend to forget importance of the issue Overreliance on external support can increase vulnerability
	Market condition	(Damodaran, 2005; Ball, Lizieri & MacGregor, 1998; Pompe & Rinehart, 2008; Lamond, Proverbs & Hammond, 2010; Fuerst & McAllister, 2009)	External market conditions have an overarching impact on the total vulnerability of all properties. Bad economic conditions can have as an multiplier effect on properties with higher vulnerability
Vulnerability of Property Value	Utility	(Johnson, Penning-Rowsell & Parker, 2007; Anderies *et al.*, 2013; Wyatt, 1995; Blackledge, 2009)(Shapiro, Davies & Mackmin,	Extent and nature of risk that exposes the intended use of building determines what effect it can have on utility of property The exposure of property depends upon its characteristics (sector, size, ownership…..and so on)

		2009)(Wyatt, 2009)(Eichholtz, Kok & Quigley, 2009)	The recovery from disaster can be cost effective if the property is insured comprehensively against flooding. This aspect depends on the insurability of the property
	Desirability	(Bell, 1998)(Fuerst & McAllister, 2011; Wheater & Evans, 2009; Bohlen & Lewis, 2009; Bruhns & Wyatt, 2011)(Lamond, Proverbs & Hammond, 2010)(Wyatt, 1995)(Wright, 2008)(Pottinger & Tanton, 2012)	Properties with flexible lease terms are more attractive for renters in commercial property market If a property has a history of flooding and has seen reduced value as a result of that the stigma might stay temporarily. It is expected that more secure locations are more desirable in property market Higher cost of preparedness against flooding can lessen desirability towards a property
	Marketability	(Damodaran, 2005; Fuerst & McAllister, 2011; Horsley, 1992; Pompe & Rinehart, 2008)(Dixon, 2009; Fuerst & McAllister, 2011; Blanchard R. D., Berry & Showalter, 2001) (Britton, Davies & Johnson, 1989)	Perception of commercial property holders towards certain properties play an important role in determining its value Loss of income as a result of flood damage and disruption can affect utility of property Easy financing such as getting mortgage and availability of cheap insurance for the property can increase marketability of a property Existing flood risk and expectation of change of risk (for example knowledge about government's plan for installation of flood defences

			in the near future) may be useful for marketability of property Flood history can have an impact on property value as a result of stigma. Interaction between profit making factors and risk reduction strategies for businesses is complicated and involved several interrelated criteria.

APPENDIX 2: QUESTIONNAIRE FOR VALIDITY ASSESSMENT

Evaluation criteria	**Questions evaluating validity criteria**	**Rating scale** **(1=not suitable at all;** **3= Suitable; 5= Perfect**	**Note**
		1 2 3 4 5	
Content validity	Is the questionnaire measuring what it intended to measure?	☐☐☐☐☐	
	Does it represent the content?	☐☐☐☐☐	
	Is it appropriate for the sample population?	☐☐☐☐☐	
	Is the questionnaire comprehensive enough to collect all the information needed to address the purpose and goals of the study?	☐☐☐☐☐	
	How would you rate the clarity of information?	☐☐☐☐☐	
Criterion validity	Do the questions adequately represent the following criteria? (Please rate them according to your understanding) 1. Respondent information	☐☐☐☐☐	

	2. Business characteristics information	□□□□□	
	3. Potential loss due to flooding based on actual experience	□□□□□	
	4. Sources of recovery	□□□□□	
	5. Rate of recovery (cost and time)	□□□□□	
	6. Preparedness against	□□□□□	
	7. General opinion and perception oriented questions regarding effect of risk of flooding on property value?	□□□□□	
Construct validity	How good do you think that the construct and the flow of the questionnaire leads to final expected outcome of the research, that is., ***to gain a better understanding of impact of flooding on the vulnerability of value of commercial properties?***	□□□□□	
Face validity	Does the instrument look like a questionnaire?	□□□□□	
	Is the questionnaire readable for a population of mixed educational background, age group and ethnicity?	□□□□□	

APPENDIX 3 COMMERCIAL PROPERTY OCCUPIERS: INFORMATION SHEET

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To
The Manager

This survey is part of a doctoral research of Miss Namrata Bhattacharya of the School of Technology, University of Wolverhampton under supervision of Dr Jessica Lamond and Dr. Felix Hammond (Director of studies). The study aims to understand the ***impact of flooding*** (damage and disruption) ***on the value of commercial properties*** in the short and long term. Please do not be concerned, receiving this questionnaire does not mean your business is at risk of flooding. The information you will provide will be held with complete confidentiality by the University of Wolverhampton and will not be passed on to any third party. The University ethics committee has approved the study. No information will be used to send you any junk mail and any further information related to the result from the research will only be sent if you opt for that.

You might be aware that recovering from flood disruption and dealing with factors affecting business continuity during and after flooding can be very pressing. This

questionnaire is designed to collect real experience of business property holders. The research intends to discover the effect of cost of damage and recovery caused by flooding on businesses and its effect on final value of the property. If you have never experienced flooding and are not likely to, your input will still be very important and helpful for the research. This information will be useful for comparison purposes. Relying on your broad experience and knowledge, please take time to answer all questions to the best of your ability. The questionnaire will take approximately 20 minutes to complete.

If you have any questions or should you require/prefer an electronic version of the questionnaire, please contact Miss. Namrata Bhattacharya using the contact information below. Please return the completed questionnaire using the self-addressed free post (no stamps required) envelope provided.

Thank you very much for your time.

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APPENDIX 4: COMMERCIAL PROPERTY OCCUPIERS QUESTIONNAIRE

SECTION A: NATURE OF RISK, IMPACT AND RECOVERY

A1.Have you been affected by flooding which damaged and/or disrupted your business since 1997?

No, I have never been flooded since 1997 ☐ (Please continue to **SECTION B**)

Yes, I have been flooded in this property since 1997 ☐ (Please continue to next question)

Yes, I have been flooded but in some other business property since 1997☐

Specify postcode of the other flooded property _____ (Please continue to next question)

2. How many times have you experienced flooding since 1997?

Once ☐ Twice ☐ Three times ☐ More than three times ☐ (Specify) _____

Please specify the year/s of flooding when your business activities were disrupted

_____

B. Now think about one flood event that caused the most damage and disruption in your business activities and answer the following:

Indicate the year of the flood event you are considering _____

Refer to the property under consideration: This property ☐ Other business property ☐

1. What was the source of flooding?

River☐ Sea ☐ Road drains ☐ Heavy rainfall ☐ Mixed sources ☐ Other specify ☐

Don't Know ☐

2. When was the flood-affected property constructed?

Pre 1920 ☐ 1921-1945 ☐ 1946-1979 ☐ Post 1980 ☐ Don't Know ☐

3. What kind of damage or disruption was caused by flooding?

A. Direct damage or disruption by flood water

Physical damage of building ☐ Damage of machinery and equipment ☐Damage to stock

Employee injury ☐ Damage inside building (windows, doors, furnishings, fittings etc.)☐Other disruption specify _____

B. Indirect damage by flood water)

Business closure ☐ Supply line disruption ☐ Access problem for customers ☐ Access problems for employees ☐ Operational disruption ☐ Neighbourhood disruption (disruption and renovation work in neighbouring business units hampering normal business operation) ☐

Other disruption specify _____

4. Now think about the monetary costs and losses that you had to incur for recovering from flood disruption. Based on the past experience, if there is a future flood indicate the potential of the following factors to incur cost on a scale of 1 to 5 (1 being no cost incurred to recover and 5 being extremely costly to recover).

	1	2	3	4	5
Structural damage repair	☐	☐	☐	☐	☐
Damage of machinery and equipment	☐	☐	☐	☐	☐
Property cleanup cost	☐	☐	☐	☐	☐
Windows, doors, furnishings, fittings repair	☐	☐	☐	☐	☐
Employee injury compensation	☐	☐	☐	☐	☐
Loss due to disruption in supply	☐	☐	☐	☐	☐
Loss of sales due to few or no customers	☐	☐	☐	☐	☐
Loss of work hour and overtime payment	☐	☐	☐	☐	☐
Data protection and recovery cost	☐	☐	☐	☐	☐
Vacant property security expenses	☐	☐	☐	☐	☐
Unrecoverable rent due to closure or no business	☐	☐	☐	☐	☐
Legal fees	☐	☐	☐	☐	☐

5. Now consider the time taken to recover from the past flood disruption. Based on your past flood experience indicate the potential amount of time that can be consumed by the following factors in recovering from flood disruption in case of future flood event on a scale of 1 to 5 (1 being recovered within short time period and 5 being most time consuming to recover).

Structural damage repair	☐	☐	☐	☐	☐
Damage of machinery and equipment	☐	☐	☐	☐	☐
Property clean up	☐	☐	☐	☐	☐
Non-structural damage repair	☐	☐	☐	☐	☐
Disruption in supply recovery	☐	☐	☐	☐	☐
Customer recovery	☐	☐	☐	☐	☐
Work recovery during time of absence	☐	☐	☐	☐	☐
Recovery service from Insurance companies	☐	☐	☐	☐	☐

6. Did you know about the flood risk of the affected property when you rented/ bought it?

Had no knowledge about flood risk ☐ Had some knowledge about the flood risk ☐

Fully aware of the flood risk ☐

7. What was the effect of flooding on your business operation?

Business operation hardly affected ☐ Business operation slightly affected ☐

Business operation seriously affected ☐ Business operation closed for some time ☐

How long was normal business operation closed as a result of flooding? _ (hours/days/months/years)
How long did it take to recover from the disruption completely?_____ (hours/days/months/years)

8. Roughly estimate the cost of flood damage and disruption on your business?
Specify approximate amount in £ _____for the year/s _____

9. Now think of the effect of flooding on your business turnover for the year of the event. Please indicate the effect of business disruption on proportion of annual turnover from that business property for that year?
No effect on annual turnover ☐ 1-5% of annual turnover ☐ 6-10% of annual turnover ☐
11-20% of annual turnover ☐21-30% of annual turnover ☐More than 30% of annual turnover ☐
Please specify _____ Don't Know ☐

10. Think of the sources of funding you have used to recover from the flood disruption. Select all that apply from the following, and indicate if you have used any other source/s of finance
Insurance☐ Commercial Loan☐ Business reserve ☐ Self-finance ☐
Don't know ☐ Other specify☐
_____

11. Have you undertaken any renegotiation on your lease terms to bring change in rental value of the property after suffering business disruption from flood? (For tenants only, *owners please go to question 13*)
No renegotiation undertaken ☐ ***(Please go to question 14)***
Yes, there was a decrease in property rent ☐ Yes, there was an increase in property rent ☐
Negotiated but there was no change in rent ☐ ***(Please go to Question 14)***
Comment:

12. Now think about the negotiation and indicate the proportion of change in value of your business property?
Proportion of value change ☐ _____percentage (%) of total rental value of the property

13. Do you think negotiations based on flood risk could have had some impact on the sale price of the property? (For property owners only, *tenants please go to question 14*)
Increase in sale price ☐ Decrease in sale price ☐ No change in sale price ☐
Indicate the proportion of change in sales price _____% of total sale price
Comment:

14. Are you aware of any other changes in market value of the flood-affected property due to risk of flooding in the past?
No, there was no change in value ☐ Yes, there was past change in value ☐
Do not know about change in value ☐
Comment:

15. Did you adopt any preventive or preparedness measures against impact of flooding before or after the flood event?

No measures adopted ☐ ***(Continue to next question)***

Measures adopted before flood event ☐ Measures adopted after flood event ☐

Please select from the following what preventive and /or preparedness measures have you adopted ***(Select all that apply)***

	Before flood event	After flood event
Subscribed to Environment Agency's flood warning system	☐	☐
Purchased flood insurance against property damage	☐	☐
Purchased business interruption insurance	☐	☐
Installed resilient fittings to the property	☐	☐
Purchased temporary flood protection	☐	☐
Installed permanent flood protection	☐	☐
Made alternative arrangements to operate business from another location	☐	☐
Have alternative source of electricity	☐	☐
Have alternative source of water storage	☐	☐
Stored fuel and batteries	☐	☐
Regular backing up of important data	☐	☐
Developed business recovery plan	☐	☐
Developed business emergency plan	☐	☐
Other specify	☐	☐

16. Now think about the surrounding of your business property and the installed community flood defences that reduced risk of flooding. Please answer the following question to the best of your knowledge

Is there any community flood defence installed near your business property that affects the flood risk of your property?

No, there are no flood defences installed ☐ ***(Please go to Question 19)***

Yes, there is flood defence installed but my property does not benefit from it ☐

Yes, there is flood defence installed and it decreased flood risk in my property ☐

Yes, there are plans for installations of new defences soon ☐

(If 'yes' please select from the given options)

Environment Agency installed flood defence ☐ Local authority installed flood defence ☐ Other ☐

Please specify_____

17. When was the flood defence measures installed?

Before the considered flood event ☐ After the considered flood event ☐

Comments:

18. Based on your knowledge and experience to what extent do you agree or disagree with the following statements on a scale of 1 to 5 (1-strongly disagree, 3-Neutral and 5-strongly agree)

	1	2	3	4	5
Value of properties will increase if the flood risk is reduced	☐	☐	☐	☐	☐
Value of property will increase if flood resilient measures are improved	☐	☐	☐	☐	☐
Properties protected by flood defence will have higher value in the market	☐	☐	☐	☐	☐
Flood defence installations can bring reduction in value of the properties just outside the defended area	☐	☐	☐	☐	☐
Flood defence installations and property value are not related	☐	☐	☐	☐	☐

Comments:

19. Consider the time before your business was affected by flood and years after the flood event (one (1) year, two (2) year and five (5) year after flood disruption)

What effect do you think flood exclusively have on the following three recovery factors in comparison to situation before flood (distinct from other market factors) on a scale 1 to 5 (1 - Condition of business worse than before flooding, 3 -no change and 5 - business improved greatly with time after recovery from flood disruption)

Recovery year after flooding	Recovery factors **(Compare conditions before and after flood)**	**1**	**2**	**3**	**4**	**5**
Year 1	Business turnover	☐	☐	☐	☐	☐
	Number of employees at business	☐	☐	☐	☐	☐
	Number of customers	☐	☐	☐	☐	☐
Year 2	Business turnover	☐	☐	☐	☐	☐
	Number of employees at business	☐	☐	☐	☐	☐
	Number of customers	☐	☐	☐	☐	☐
Year 5	Business turnover	☐	☐	☐	☐	☐
	Number of employees at business	☐	☐	☐	☐	☐
	Number of customers	☐	☐	☐	☐	☐

Comments:

SECTION B: FLOODING AND PROPERTY VALUE: VIEWPOINTS (The following general opinion questions are for all respondents)

1. In the light of the changing risk of flooding in the UK to what extent do you agree or disagree with the following statements. The statements corresponds to the effect of flooding on property use, their desirability and attractiveness in the real estate market on a scale of 1 to 5 (1-strongly disagree, 3- neutral and 5-strongly agree)

	1	2	3	4	5
Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future	☐	☐	☐	☐	☐
Loss of income from flood risk affected properties can negatively affect the demand for such properties in the real estate market	☐	☐	☐	☐	☐
Prime location of property is a more important factor in determining property marketability than flood risk	☐	☐	☐	☐	☐
Easier availability of flood insurance can encourage business owners/ occupiers to opt for insurance against flooding	☐	☐	☐	☐	☐
Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market	☐	☐	☐	☐	☐
Once a flood disrupted property loses its value in property market it is difficult to get higher value for the property again	☐	☐	☐	☐	☐
Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market	☐	☐	☐	☐	☐
Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding	☐	☐	☐	☐	☐
Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market	☐	☐	☐	☐	☐
Properties with history of reduced value as a result of flooding always have low demand in the property market	☐	☐	☐	☐	☐
Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future	☐	☐	☐	☐	☐
Lowering flood risk by installing resilient measures does not affect property value in the long term	☐	☐	☐	☐	☐
More loss of income during flood disruption results in longer recovery time	☐	☐	☐	☐	☐
Longer recovery time means higher loss of utility and income from the affected property	☐	☐	☐	☐	☐
Suitability for mortgage finance makes a property more attractive in the property market in spite of its high risk of flooding	☐	☐	☐	☐	☐
High flood risk and disruption of business encourages property occupiers to move out to a lower flood risk zone	☐	☐	☐	☐	☐

Comments:

SECTION C: BUSINESS AND OWNERSHIP INFORMATION (Questions are for all respondents)

Please provide little background information about you and your business organization

1. Name of the organization:

2. Position in the organization:

Director ☐ Senior manager ☐Middle management staff ☐ Operational staff ☐Other ☐

3. Company address:

Telephone (Preferred) ☐

Email (Preferred) ☐

Prefer to be anonymous ☐

4. How many years have you been doing business in the present address? _____years

5. What type of business are you engaged in?

Manufacturing ☐ Wholesale and Retail trade ☐ Transport and Storage ☐ Service ☐Leisure and entertainment ☐ Other ☐

6. Approximately how many people are employed in this organization?

1-10 ☐11-20 ☐ 21-50 ☐ 51-250 ☐ More than 250

7. What is your primary service area (market)?

Local ☐ Regional ☐ National ☐ International ☐

8. Which of the following best suits your business type?

Individual firm single location ☐ Individual firm multiple location ☐ Franchise ☐

Part of a business chain ☐

9. On what terms do you occupy this property?

Owned ☐ Rented ☐

If rented what kind of lease agreement do you have for the property?

FRI (Full repair and Insurance) ☐ Internal Repairing and Insuring ☐

Other (Please specify) ☐ _____

Thank you for your assistance with this questionnaire

Any further comments? (Please attach more pages if you like)

Would you be willing to participate in a further phase of this research?

Yes ☐No ☐

Kindly return the questionnaire using the self-addressed free post (no stamps required)

APPENDIX 5: COMMERCIAL PROPERTY EXPERTS' INFORMATION SHEET

IMPACT OF FLOODING ON VALUE OF COMMERCIAL PROPERTIES

This survey is part of doctoral research of Miss Namrata Bhattacharya of the School of Technology, University of Wolverhampton under supervision of Dr Jessica Lamond and Dr Felix Hammond (Director of studies). The study aims to understand the impact of flooding (damage and disruption) on the value of commercial properties in the short and long term.

You might be aware of the fact that recovering from flood disruption and dealing with factors affecting business continuity during and after flooding can be very pressing and might have the potential to affect the value of property. This questionnaire is designed to collect real market experience of commercial property agents. If the properties you are dealing in have never been flooded or have been indirectly affected, the information will still be very important and helpful for the research. This information will be used for comparative purposes.

The information you will provide will be held with strict confidentiality by the University of Wolverhampton and will not be passed on to any third party. The information will be used for academic purpose only and only summaries of the results will be publicized. The University of Wolverhampton ethics committee has approved the study. No information will be used to send you any junk mail. Your valuable input into the following questionnaire would be extremely useful to draw on your expert experience and knowledge. Relying on your broad experience and knowledge, please take time to answer all questions to the best of your ability. The questionnaire will take approximately 10 minutes to complete. If you have any questions or require further information please contact Miss. Namrata Bhattacharya using the contact information below.

Thank you very much for your time.

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APPENDIX 6: COMMERCIAL PROPERTY EXPERTS' QUESTIONNAIRE

1. Respondent Information

Name	Click here to enter text.
Company	Click here to enter text.
Address 1	Click here to enter text.
Address 2	Click here to enter text.
City/ Town	Click here to enter text.
Post Code	Click here to enter text.
Email	Click here to enter text.
Phone Number	Click here to enter text.

2. How long have you been dealing in commercial properties in your practice?

1-5 years	☐
6-10 years	☐
11-15 years	☐
16-20 years	☐
More than 20 years	☐
Other (Specify) Click here to enter text.	

3. Which of the following types of properties you frequently deal in (Tick all that apply)

Retail	☐
Office	☐
Manufacturing	☐
Wholesale	☐
Service	☐
Leisure	☐
Other (Specify)	

4. Have you ever dealt in?

Properties directly affected by flooding	☐
Properties indirectly affected by flooding	☐
Neither (Go to Question 9)	☐

5. Have you ever faced problems dealing in properties due to their perceived risk of flooding? Tick that apply

No (If NO please go to question number 9)	☐
Yes, had renting refused	☐
Yes, had sales refused	☐
Yes, had to go through renegotiation of property value	☐
(If YES can you estimate the proportion of properties at risk in this way in your portfolio) Percentage (%) Click here to enter text.	

6. What happened as a result of the problem? Tick all that apply

There was negotiation on behalf of landlords/owners (please continue to question 7)	☐
There was negotiation from tenants side (please continue to question 7)	☐
Landlord/owner invested in flood protection measures in the sales refused property and is sold (Please go to question 9)	☐
Landlord/owner invested in flood protection measures in the sales refused property and is not sold yet (Please go to question 9)	☐
Landlord/ owner invested in flood protection measures in rental refused property and is rented (Please go to question 9)	☐
Landlord/ owner invested in flood protection measures in rental refused property and is not rented yet (Please go to question 9)	☐
Landlord/ owner did nothing for the sales or rental refused property (Please go to question 9)	☐
Other please comment in the space provided	

7. Please state the effect of any negotiation on the rental value of property due to flood risk? Tick all that apply

On Landlord's behalf Rental value increased because flood risk decreased	☐
On Landlord's behalf Rental value decreased because flood risk increased	☐
On Landlord's behalf No changes made	☐
On Tenant's behalf Rental value increased because flood risk decreased	☐
On Tenant's behalf Rental value decreased because flood risk increased	☐
On Tenant's behalf No changes made	☐
Please comment in the space provided	

8. Please state an average proportion of change (increase or decrease) in the market value of property as a result of negotiations due to effect of flood risk?

	Landlord's behalf	Tenant's behalf
On Landlord's behalf Rental value increased because flood risk decreased	Choose an item.	Choose an item.
On Landlord's behalf Rental value decreased because flood risk increased	Choose an item.	Choose an item.
On Tenant's behalf Rental value increased because flood risk decreased	Choose an item.	Choose an item.
On Tenant's behalf Rental value decreased because flood risk increased	Choose an item.	Choose an item.
Other (please specify the value in the space provided)		

9. In your opinion and experience what influence do the following have on market value of commercial properties on a scale of 1 to 5 (1-no effect and 5 having most effect and Not Related)?

	1	2	3	4	5	Not related
Properties located at high risk of flooding	☐	☐	☐	☐	☐	☐
Properties located at low risk of flooding	☐	☐	☐	☐	☐	☐
Defences installed by Environment Agency	☐	☐	☐	☐	☐	☐
Existence of property level flood defences	☐	☐	☐	☐	☐	☐
Plan for future defence installation	☐	☐	☐	☐	☐	☐
Flood history of the area	☐	☐	☐	☐	☐	☐
Availability or cost of flood insurance	☐	☐	☐	☐	☐	☐
History of reduced value of this property due to flooding	☐	☐	☐	☐	☐	☐
Proximity to customer base	☐	☐	☐	☐	☐	☐
Proximity to supplier base	☐	☐	☐	☐	☐	☐

Easy availability of mortgage	☐	☐	☐	☐	☐	☐
Prime location	☐	☐	☐	☐	☐	☐
Building use (retail, industrial, wholesale....)	☐	☐	☐	☐	☐	☐
Building characteristics (age, material, size, type)	☐	☐	☐	☐	☐	☐
Other (specify the most important aspect you feel should be included in the above list in space provided)						

10. Now indicate using the drop down menu whether (all other things being equal) the presence of flood defences or other protection makes a difference to property value. In your judgement estimate the proportion of change in rental and sales value for the following comparative properties:

	Rental value reduction %	Sale Value reduction %
Property value in high flood risk zone without flood defence protection vs. Property value without flood risk	Choose an item.	Choose an item.
Property value in high flood risk zone with flood defence protection vs. Property value without flood risk	Choose an item.	Choose an item.
Properties in medium risk zone without flood defence protection vs. Property value without flood risk	Choose an item.	Choose an item.
Property value in medium risk zone with flood defence protection vs. Property value without flood risk	Choose an item.	Choose an item.
Please comment		

Thank you for your assistance with this questionnaire

Any further comments? (Please attach more sheets if you like)

Click here to enter text.

Would you be willing to participate in a further phase of this research? Yes ☐No ☐

APPENDIX 7: VULNERABILITY OF VALUE: SUBCRITERIA RANKING SUMMARY

Based on property type (M = Manufacturing; WR- Wholesale and Retail; S- Service; O- Other; R-Ranks)

(Agreement scale is divided between 1 and 5 where 1 indicates total disagreement, 3 indicates neutral view and 5 indicates total agreement. Therefore any agreement level over 3 is considered to be part of higher agreement and weighted accordingly. With perception of higher vulnerability of value highest weight of 1 is assigned, followed by neutral agreements of 0.5 and for lower agreements a weight of 0 is provided)

Sub-criteria		**Wakefield_ Average**				**Wakefield_ Ranks**				**Sheffield_ Average**				**Sheffield_ Ranks**			
Perception	**How perception effects vulnerability of property value**	**M**	**WR**	**S**	**O**	**MR**	**WR_R**	**SR**	**OR**	**M**	**WR**	**S**	**O**	**MR**	**WR_R**	**SR**	**OR**
F1:Business properties within high and medium flood risk areas will experience more loss of income as a result of flooding in the future (Extent and nature of risk : Usability)	Respondents with higher agreement to the statement are expected to have less desirability to deal in high and medium risk properties as a result of their expected reduced utility, therefore value is more vulnerable (higher vulnerability assigned to only flood zone 2 and 3 properties)	4	4	4	4	1	1	1	1	4	4	4	4	1	1	1	1
F2:Loss of income from flood affected properties can negatively affect the demand for such properties in the real estate market (Extent and nature of risk) (Usability)	Respondents with higher agreement to this statement are expected to perceive that with higher loss of income the properties will lose its demand in the market, therefore value is more vulnerable (Higher vulnerability assigned to only flooded properties)	4	3	4	4	1	0.5	1	1	4	4	4	3	1	1	1	0.5
F3:Prime location of property is a more important factor in determining property marketability than flood risk (Property Characteristics: Usability)	Respondents with higher agreement to such statement indicates their perception towards risk is undermined by other factors of profit making and are willing to pay more for such properties, therefore value is less vulnerable here	4	4	3	3	0	0	0.5	0.5	3	3	3	4	0.5	0.5	0.5	0
F4:Easier availability of flood insurance can encourage business owners/ occupiers to opt for insurance against flooding (Insurability: Usability)	Respondents with higher agreement are expected to pay for insurance and therefore enhance property resilience and reduce risk, therefore value will be less vulnerable	4	3.5	4	4	0	0	0	0	4	4	4	4	0	0	0	0
F5:Cheaper flood insurance premium for risk prone properties can enhance their desirability in the real estate market (Insurability: Usability)	Respondents with higher agreement to this statement indicate that they are not willing to pay more for risk prone properties, therefore value is vulnerable (Higher vulnerability is assigned to high risk prone properties)	3	4	4	3	0.5	1	1	0.5	4	4	4	4	1	1	1	1
F6:Once a flood disrupted property loses its value in property market it is difficult to get higher value for the	Respondents with higher agreement are expected to have the perception of stigma associated with flood affected properties, therefore they will not be	4	3	4	4	1	0.5	1	1	4	3.5	4	4	1	1	1	1

property again (Desirability associated with only flood disrupted properties)	willing to pay more for the property, therefore value is vulnerable here																
F7:Flexible lease terms can positively affect the desirability of risk affected properties in the real estate market (Property Characteristics: Desirability)	Respondents with higher agreement indicate that they are willing to pay for properties at higher risk because of flexible lease terms, therefore vulnerability of value of such properties is lower	4	3	3	3	0	0.5	0.5	0.5	4	3	4	3	0	0.5	0	0.5
F8:Properties having higher expected rate of income generation are more desirable in the property market in-spite of their high risk of flooding (Desirability)	Respondents with higher agreement indicate that they perceive properties with higher income generation potentials are more desirable in the market even if they have higher probability of risk of flooding, therefore vulnerability of value of such properties is lower	3	4	3	3	0.5	0	0.5	0.5	4	3	3.5	3	0	0.5	0	0.5
F9: Properties with history of reduced value as a result of flooding always have low demand in the property market (Desirability)	Respondents with higher agreement indicate that once a property has experienced any negotiation in terms of flood risk, it becomes less desirable in the market, therefore its value becomes more vulnerable	4	3	3	3	1	0.5	0.5	0.5	4	3	4	3	1	0.5	1	0.5
F10: Properties with chances of improved protection against flood risk (installed defence, resilient measures) are expected to achieve higher value in property market (Expectation of change in risk: Marketability)	Respondents with higher agreement indicate that they perceive if the property is made resilient against flooding the value of the property will not be affected and desirability can increase in future, therefore vulnerability of value will be lower	4	3	3	3	0	0.5	0.5	0.5	4	3	3.5	3	0	0.5	0	0.5
F11:Investing in mitigation and preparedness measures against flooding can have positive effect on demand for the property in future (Cost of preparedness and mitigation) (Marketability)	Respondents with higher agreement to the statement are expected to pay higher for properties with resilient measures installed either on community basis or at property level, therefore vulnerability towards value of such properties will be lower (Properties with preparedness measures were assigned lower vulnerability of value)	4	3	4	4	0	0.5	0	0	4	4	4	4	0	0	0	0
F12:Lowering flood risk by installing resilient measures does not affect property value in the long term (Expectation in change in risk: Marketability)	Respondents with higher agreement to this statement indicate that they are not willing to pay for long term resilience of the property and even with higher risk vulnerability of value of such properties will be lower	2	4	3	3	1	0	0.5	0.5	3	3	3	3	0.5	0.5	0.5	0.5
F13:More loss of income during flood	Respondents with higher agreement perceive that	4	4	4	4	1	1	1	1	4	4	4	4	1	1	1	1

disruption results in longer recovery time (Usability)	flood disruption and longer recovery means higher loss of income therefore higher risk of getting back in business, thus higher impact on vulnerability of value																
F14:Longer recovery time means higher loss of utility and income from the affected property (Usability)	Respondents with higher agreement indicate perception that with higher loss of utility of property value can be more vulnerable (ranks only assigned to flood affected properties)	4	3	4	4	1	0.5	1	1	4	3.5	4	4	1	1	1	1
F15:Suitability for mortgage finance makes a property more attractive in the property market in spite of its high risk of flooding (Financing: Marketability)	Respondents with higher agreement indicate that suitable finance has higher priority over flood risk in the market therefore vulnerability of value for such properties will be lower	4	3	3	3	0	0.5	0.5	0.5	3	3	3	3	0.5	0.5	0.5	0.5
F16:High flood risk and disruption of business encourages property occupiers to move out to a lower flood risk zone (Expectation of change in risk) (Marketability)	Higher agreement indicates respondents are willing to move out of the significant flood risk area, therefore making vulnerability of value higher for those properties (ranks assigned to properties at high risk zone)	3	3	3	3	0.5	0.5	0.5	0.5	3.5	3	4	4	1	0.5	1	1

APPENDIX 8: DISSEMINATION OF RESEARCH

Conference papers:

Bhattacharya-Mis, N., Lamond, J (2014) Socio-economic complexities of flood memory in building resilience: An overview of research *Procedia Economics and Finance* (in press) ***4th International Conference on Building Resilience, Building Resilience*** 2014, 8-10 September, Salford UK

Bhattacharya-Mis, N., Lamond, J. (2014) An investigation of patterns of response and recovery among flood-affected businesses in the UK: a case study in Sheffield and Wakefield ***4th International Conference on Flood Recovery, Innovation and Response (FRIAR) IV***. 18th June – 20th June, ISSN 1743-3541 (on-line) WIT Transactions on Ecology and The Environment, Vol 184, © 2014 WIT Press

Bhattacharya, N., Lamond, J. (2013) Methodological challenges in understanding impact of flooding on property value: ***LCSS PhD conference 2013***; Kings College London

Bhattacharya, N., Lamond, J., Proverbs, D., Hammond, F., Searle, D. (2012). A framework for participatory assessment of vulnerability of commercial property values to flooding in the UK***. 3rd International Conference on Flood Recovery, Innovation and Response (FRIAR) III***. 29th May – 1st June, WIT Press, Croatia.

Lamond, J., Bhattacharya, N., Bloch, R. (2012) The role of solid waste management as a response to urban flood risk in developing countries, a case study analysis. ***3rd International Conference on Flood Recovery, Innovation and Response (FRIAR) III***, 29th May – 1st June, WIT Press, Croatia.

Bhattacharya, N., Lamond, J. (2011) A Review of the Flood risk situation in African growing economy. ***International conference on Urban Flood Risk Management***, University of Technology, 21st – 23rd September, Graz, Austria

Bhattacharya, N., Lamond, J., Proverbs, D., Hammond, F. (2011) Impact of Flooding on the Value of commercial properties in the UK. ARCOM Doctoral

Workshop, ***International Conference on Building Resilience***,19th – 21st July Dambulla, Srilanka

Bhattacharya, N., Lamond, J., Proverbs, D.(2011) Flood vulnerability and hazard adjustment for UK commercial sector, ***International Conference on Disaster Resilience***, 19th – 21st July Dambulla, Srilanka

Bhattacharya, N., Alkema, D., Kingma, N. (2010) Integrated flood modeling for hazard assessment of Barcelonnette town, France., ***Mountain Risk Conference***, Florence, Italy

Bhattacharya, N., Kingma, N., Alkema, D. (2010) Flood risk assessment of Barcelonnette for estimation of economic impact on the physical elements at risk in the area., ***Mountain Risk Conference***, Florence, Italy

In addition to paper presentation four posters are also presented in two of the above conferences and three posters were presented internally

Journal papers:

Bhattacharya, N., Lamond, J., Proverbs, D., Hammond, F.(2013) Developing Conceptual Framework for Understanding Vulnerability of Commercial Property Values towards Flooding, *International Journal of Disaster Resilience in Built Environment* , 4(3) pp-334-351

Bhattacharya, N., Lamond, J. Mapping Community Knowledge of Vulnerability of Value: A Case Study in the UK, *International Journal of Safety and Security Engineering* (peer reviewed) Expected to be published in 2014

Research Reports

Lamond, J., Bhattacharya, N., Squires, G., Everett, Glyn (2013) Impact of flood defences on property values, regeneration and development, Report published internally by Environment Agency in collaboration with University of West of England.

Bhattacharya, N., Lamond, J., Paccagnan, V. (2012) Impact of flood defences on the value of residential and commercial properties: Final report; Internal Publication; Environment Agency in collaboration with University of West of England

Policy Research paper:

Jha, A ., Lamond, J ., Bloch., R , Bhattacharya, N ., Lopez, A ; Papachristodoulou, N ., Bird, A ., Proverbs, D ., Davies, John ., Barker, R .(2011) Five feet high and rising : cities and flooding in the 21st century. Policy Research Working Paperno:WPS5648, WorldBank http://wwwwds.worldbank.org/servlet/main?menuPK=64187510&pagePK=64193027&piPK=64187937&theSitePK=523679&entityID=000158349_20110503095951

Book Sections:

Jha, A ., Lamond, J ., Bloch., R , Bhattacharya, N ., Lopez, A ; Papachristodoulou, N ., Bird, A ., Proverbs, D ., Davies, John ., Barker, R .(2012) Cities and Flooding: A guide to integrated urban flood risk management for the 21st Century, The World Bank, GFDRR; Washington D.C.

Forthcoming publications:

Bhattacharya-Mis, N., Lamond, J. (2014) Towards an integrated framework for building resilience using flood memory in built environment, 2nd International Conference on Urban Sustainability and Resilience, 3rd -5th November UCL, London

Namrata Bhattacharya-Mis, Rotimi Joseph, David Proverbs, Jessica Lamond An overview of the grass-root preparedness against potential flood risk among residential and commercial property holders, *International Journal of Disaster Resilience in the Built Environment* (under review expected to be published in March 2015)